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Tobias R. Rühl
Michael Stein

The Cost of New Information – ECB Macro Announcement Impacts on Bid-Ask Spreads of European Blue Chips

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Technische Universität Dortmund, Department of Economic and Social Sciences
Vogelpothsweg 87, 44227 Dortmund, Germany

Universität Duisburg-Essen, Department of Economics
Universitätsstr. 12, 45117 Essen, Germany

Rheinisch-Westfälisches Institut für Wirtschaftsforschung (RWI)
Hohenzollernstr. 1-3, 45128 Essen, Germany

Editors

Prof. Dr. Thomas K. Bauer
RUB, Department of Economics, Empirical Economics
Phone: +49 (0) 234/3 22 83 41, e-mail: thomas.bauer@rub.de

Prof. Dr. Wolfgang Leininger
Technische Universität Dortmund, Department of Economic and Social Sciences
Economics – Microeconomics
Phone: +49 (0) 231/7 55-3297, email: W.Leininger@wiso.uni-dortmund.de

Prof. Dr. Volker Clausen
University of Duisburg-Essen, Department of Economics
International Economics
Phone: +49 (0) 201/1 83-3655, e-mail: vclausen@vwl.uni-due.de

Prof. Dr. Christoph M. Schmidt
RWI, Phone: +49 (0) 201/81 49-227, e-mail: christoph.schmidt@rwi-essen.de

Editorial Office

Sabine Weiler
RWI, Phone: +49 (0) 201/81 49-213, e-mail: sabine.weiler@rwi-essen.de

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Tobias R. Rühl and Michael Stein[1]

The Cost of New Information – ECB Macro Announcement Impacts on Bid-Ask Spreads of European Blue Chips

Abstract

Bid-ask spreads using intraday data reveal significant sensitivity to European Central Bank (ECB) macro announcements. Effects are strongest for announcements that comprise unexpected information or a change in interest rates, and spreads rise sharply during the minutes surrounding interest rate or other important macroeconomic announcements by the ECB. Both Euro area stocks (of German DAX 30 and French CAC 40) and non-Euro stocks (of FTSE 100) have been used for comparative reasons. All results are robust to changes in specification and when being controlled for normal daytime-dependent frictions or other macroeconomic announcements.

JEL Classification: G14, G18, E52

Keywords: Market microstructure; transaction costs; bid-ask spreads; ECB; announcement effects

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1 Both University of Duisburg-Essen – All correspondence to: Michael Stein, Faculty of Economics and Business Administration, University of Duisburg-Essen, Universitätstr. 12, 45117 Essen, Germany. E-Mail: michael.stein@uni-due.de.

1. Introduction

Macroeconomic announcements and their effects on security prices are of crucial importance for the understanding of market behavior, especially in recent years, since the onset of the financial market crisis and the subsequent global economic slump have shown that market participants do base their decisions on major economic news and information. In this study, we focus on the direct short-term effects of announcements made by the European Central Bank (ECB). Using intraday data that consists of each single trade information for the securities used, we investigate whether and how bid-ask spreads are affected by ECB decisions and announcements.

Bid-ask spreads play a substantial role in the evaluation of market functioning and behavior, and have accordingly been well researched in previous market microstructure investigations. For more than four decades researchers have analyzed the microstructural behavior of markets in an effort to reveal the driving factors behind observable differences in buy and sell prices for immediate trade executions. Most literature on market microstructure with a focus on macroeconomic announcements investigates impacts on foreign exchange markets rather than on stock prices. Bossaerts and Hillion (1991), Bollerslev and Melvin (1994) and Andersen et al. (2007) for example provide studies in that area. Several authors have focused particularly on the influence of (monetary) news announcements on the microstructure of foreign exchange markets (e.g. Ederington and Lee (1993), DeGennaro and Shrieves (1997) and Bauwens et al. (2005)).

Studies investigating the effects on the stock market usually focus on the implications for market volatility or returns arising from macroeconomic news. Jubinski and Tomljanovich (2013) and Savor and Wilson (2013), for example, examine return effects due to macro impacts, but to the best of our knowledge there is no study directly investigating the consequences of ECB announcements on the bid-ask spread using intraday data. Considering the

effects of major announcements as highly important in the context of stock market pricing, we analyze the impact of both interest rate decisions and press conferences by the ECB. Using a general market model, we derive the theoretical reasoning for alterations of spreads based on macroeconomic announcements. The market model is empirically tested with European stock market data on trade-by-trade frequency. Our findings reveal a temporary but sharp rise in spreads of stocks traded at high frequency around a macroeconomic announcement by the ECB. This is of particular interest to policy-makers, institutions and market participants, as enhanced knowledge of the spread formation helps to improve market and trading efficiency, as well as exchange competitiveness. Since the bid-ask spread can be seen as a measure of certain transaction costs (Demsetz (1986))[1], knowledge concerning structurally higher spreads surrounding ECB announcements even helps investors who are not interested in day trading. Avoiding periods of high transaction costs for portfolio adjustments thus leads to a better medium- or long-term performance.

Market microstructure literature concerning bid-ask spreads is the most important background for our approach and study setup. Existing studies mostly discuss dealer markets that are among the quote-driven types of market structure, as opposed to order-driven markets, and can be broadly classified into three categories.

The first deals with the pure measurement of spreads and includes among others the seminal studies by Roll (1984) and Choi et al. (1988). These try, essentially, to measure the spread by using the covariance in price changes, which must be negative if there are differences between ask and bid prices[2]. The second category of papers aims at further understanding

[1] The costs for a round trip transaction in one stock.

[2] Trades can be executed either at the ask or at the bid price. Assuming all other variables, as well as the equilibrium price, are constant, then if the last trade is at the ask (bid), the next trade can only be at the same price or below (above). So after a positive price change (from bid to ask) the price can stay the same or decrease (from ask to bid). This should lead to negative autocorrelation in price changes. This assumption became the standard for trade-by-trade analysis.

the drivers of spreads and suggests an order-processing component and an inventory component, on either a theoretical or an empirical basis. An order-processing component reflects the compensation for the dealer with respect to his expenditures for service provision. Such expenditures may arise from salaries for employees, costs of technical equipment or office rental, among other things. The inventory component describes the influence of a dealer's inventory position in the relevant asset. Holding a specific inventory induces holding costs such as opportunity costs or the costs of carrying the price risk. If the number of shares a dealer holds exceeds his equilibrium amount, he will lower both bid and ask prices to attract more buyers and fewer sellers, pushing his position back to the equilibrium level. So the inventory component will influence the position of the bid and ask prices - but not necessarily the size of the spread. Papers in this category include those of Stoll (1978), Amihud and Mendelson (1980), Ho and Stoll (1981), Ho and Macris (1984), Stoll (1989), Hasbrouck and Sofianos (1993), Madhavan and Smidt (1993), Madhavan and Sofianos (1998) and Hansch et al. (1998), among others. The findings concerning the importance of the inventory component are, however, mixed.

The final category of classical microstructure papers also employs order processing components, but additionally deals with the role of information. An information component captures the influence of asymmetric information in the market on the spread. If some investors are better informed than the market maker, they are able to make arbitrage profits by buying stocks that are currently underpriced and selling stocks that are overpriced (relative to their view reflecting the information). In order to offset those losses at least partially, market makers are expected to set a higher spread. Given that information asymmetry in the market rises and all other influences remain constant, the spreads also have to rise accordingly. Studies in this category are provided by Glosten and Milgrom (1985), Easley and O'Hara (1987), Glosten (1987) and Easley et al. (1996). There are also some mixed models which incorporate inventory and asymmetric information effects; these include the studies

by Glosten and Harris (1988), Hasbrouck (1988), Madhavan and Smidt (1991) and Lyons (1995), among others.

While microstructure literature of the category that uses information effects is of particular importance to our study, so are general studies including information effects from announcements. Empirical evidence on this is mixed, depending on which type of announcement is under investigation. Fleming and Remolona (1999), Frino and Hill (2001) and Erenburg and Lasser (2009) are examples of where effects on spreads are found, at least for some kinds of announcements. Morse and Ushman (1983), on the other hand, do not find significant changes in spreads connected with earnings announcements, but surrounding large price changes which are used as an indicator for new information. Bomfim (2003) and Jubinski and Tomljanovich (2013) analyze the effect of federal fund rate announcements on intraday returns controlled for volatility, and Kurov (2012) investigates how the effects of monetary announcements depend on the state of the business cycle. A long-term study by Savor and Wilson (2013) identifies a significantly higher stock market return for days with scheduled macroeconomic announcements using daily returns.

As noted above, we use trade-by-trade stock data and estimate the effects from ECB announcements, investigating reactions of the bid-ask spread rather than those of the (middle) price. The basis for our investigation and theoretical reasoning is presented in the next section: a formal market model which can be used for dealer markets as well as for continuous order-driven markets, or for mixed forms. This enables us to use data on different stocks regardless of the way they have been traded, which is paramount when analyzing market structure-type effects across different countries as trading systems. Section 3 describes the empirical setup and methodology for identifying the spread size and announcement effects, as well as the data used. Section 4 discusses the results and Section 5 provides economic implications and discussions. Concluding remarks follow in Section 6.

2. Theoretical model

We discussed several driving factors for the spread of financial assets in the introductory section. Based on this, we provide a very general framework with a market model for the bid and ask formation in this section. It is very broad in the sense that it allows for different types of effects and markets. Specific types of market, such as the monopolistic dealer market, can be derived as special cases from the general model. Our model thus includes the classical factors order processing costs, inventory costs and an asymmetric information component. We consider it straightforward to use a general design of the model that helps one understand the theoretical considerations behind movements in spreads that have become well used in the relevant fields of research, regardless of which kind of market is under investigation. This will enable us later to discuss our empirical findings along a theoretical framework, rather than referring cryptically to "informational effects".

The ask and bid prices, $P^a_{i,t}$ and $P^b_{i,t}$ are defined as follows for each market participant i at time t[3]:

$$P^a_{i,t} = P^*_{i,t} + \frac{1}{2}T_i + c_1 A_{i,t} - c_2 I_{i,t} \tag{1}$$

$$P^b_{i,t} = P^*_{i,t} - \frac{1}{2}T_i - c_1 A_{i,t} - c_2 I_{i,t} \tag{2}$$

In this specification, the bid and ask prices are a function of the equilibrium price $P^*_{i,t}$, an order processing cost component T_i, an asymmetric information component $A_{i,t}$ and an inventory cost component $I_{i,t}$. The order processing or "transaction" costs T_i (referring to one round-trip transaction, that is, a consecutive buy and sell) are assumed to be constant over time. Regarding the inventory cost component, a (too) short position in a security is

[3] $P^a_{i,t}$, for instance, represents the price at which participant i would sell stocks and not necessarily a price actually observable on the market.

marked by$I_{i,t} < 0$ and vice versa (if $I_{i,t} = 0$, the market participant has the desired (zero) position). Asymmetric information to be present in the market is expected by individual i whenever $A_{i,t} > 0$. Note that $A_{i,t}$ can also be interpreted as the component measuring the perception by individual i of market uncertainty. The influence of each component influence is determined by the respective factor c.

For the equilibrium price representing the value of the asset assumed by individual i at time t, we define an autoregressive system. The change in the equilibrium price then evolves according to a random walk:

$$P^*_{i,t} = P^*_{i,t-1} + \varepsilon_{i,t} \tag{3}$$

As in Glosten and Harris (1988) and many studies that followed, the error term $\varepsilon_{i,t}$ is i.i.d. and is due to the arrival of new publicly available information. It describes the update of the belief concerning the real value of the asset due to new information. From all the definitions above we can finally derive the general market participant's spread as:

$$S_{i,t} = P^a_{i,t} - P^b_{i,t} = 2c_1 A_{i,t} + T_i \tag{4}$$

The inventory component drops out because it influences only the location and not the size of the spread[4]. The asymmetric information component is modeled as follows:

$$A_{i,t} = c_3 D_{i,t} + v_{i,t} \tag{5}$$

Specific dates are important and incorporated by $D_{i,t}$, since regular scheduled macroeconomic announcements, for example, can have an impact on spreads. The error term $v_{i,t}$ is another i.i.d. zero-mean process. It incorporates any news which has an influence on the belief about asymmetric information. In empirical investigations asymmetric information is modeled using various explanatory variables such as transaction volume (since high volumes might be seen as indicators of informed trading) or return volatility (increasing uncertainty).

[4]See Appendix for more discussion and references.

We will discuss this further in the empirical section.

At this point it is worth pointing out that the individual spread $S_{i,t}$ describes the spread of any one market participant. In the case of a (monopolistic) dealer market, the above equation for the spread gives the actual spread of the dealer and so of the market, but in the case of a competitive dealer market, a limit order market, or mixed forms of these, one has rather to focus on the inside spread. This is because best bid and best ask prices do not have to be posed by the same market participant:

$$S_t^* = P_{i,t}^a - P_{j,t}^b = P_{i,t}^* + \frac{1}{2}T_i + c_1 A_{i,t} - c_2 I_{i,t} - P_{j,t}^* + \frac{1}{2}T_j + c_1 A_{j,t} + c_2 I_{j,t} \tag{6}$$

This defines the inside spread, where i is the individual who poses the best ask and j is the individual who poses the best bid. This would be a simple but broad representation of the relevant spread in a competitive market, which applies to most stock markets nowadays. One can define the components of the spreads in even more detail, for example, by describing the asymmetric information component by including risk aversion, as it is done by Ho and Stoll (1981). This is not, however, necessary for the purposes of this study. We provide further insight into the workings of the general model and the classical market examples in the Appendix.

The theoretical considerations in this section form the basis for the following empirical investigation. If, for example, one observes higher spreads after an announcement while the number of participants does not shrink, one can take this as an empirical indication of higher asymmetric information after the announcement (Frino and Hill (2001)). It can be due either to market participants being better informed because of superior information or to a higher degree of uncertainty about the fundamental value of the asset. If a market participant faces a higher uncertainty about the fundamental value he will increase his spread because the chance of a loss due to a mistake in his own beliefs concerning the prices will rise. If, however, one observes tighter spreads after an announcement, one can expect the announce-

ment to have removed uncertainty. In this case, the reduced information asymmetry should lessen the incentive of market makers to compensate with higher spreads. Notably, these effects usually relate to the span that bid and ask builds around the equilibrium price, which itself might change drastically or not at all. Bomfim (2003) and Jubinski and Tomljanovich (2013), for example, put their focus on these changes in the price itself, while our study, as mentioned above, provides an analysis of the impact that news has on the differences between buy and sell prices. While our theoretical model was used to formalize the effects of different spread factors that have become more or less standard in the related literature, and to understand the workings of the different components, the empirical investigation in the next section has the aim of showing whether there are any such effects on spreads and where they may originate.

3. Empirical setup

3.1. Derivation of the empirical estimation equation

To derive the empirical estimation equation, we take the inside spread from our theoretical considerations in the previous section. We average the spread over one-minute periods. Here the individuals i and j can change from transaction to transaction, depending on who poses the most competitive prices over time. It is important to note the beneficial effect of aggregating data to the minute frequency: trades may occur in heavily differing frequency when, for example, several trades are executed during one second and no shares are traded for several seconds during other phases. Adjusting to a one-minute frequency solves this problem by providing equidistant observations. Even though one loses some information, using trade-by-trade data first as a basis still retains its favorability over lower-frequency raw data - as the averaging of single-trade spreads is different from calculations using the last prices of one-minute or five-minute intervals. Furthermore, the averaging deals with some issues concerning the inventory component: on the individual level the inventory

position should have an influence only on the spread location and not on the spread size, as already mentioned in our theoretical section. However, if the inside spread is considered, the inventory effects can lead to a change in spread size for example, if one participant poses the best ask price after buying stocks and the best bid posed by another market participant has not changed.

But the same reasoning can also lead to a widening of the spread, and here is no reason for a structural change of the size of the inside spread due to inventory effects. So spread size changes due to this should have a mean of zero and the average spread over the one-minute interval should be free from inventory effects[5].

The average inside spread becomes:

$$\bar{S}_t^* = \bar{P}_{i,t}^* + \frac{1}{2}\bar{T}_i + \bar{c}_{1,i}\bar{A}_{i,t} - \bar{c}_{2,i}\bar{I}_{i,t} - \bar{P}_{j,t}^* + \frac{1}{2}\bar{T}_j + \bar{c}_{1,j}\bar{A}_{j,t} + \bar{c}_{2,j}\bar{I}_{j,t} \tag{7}$$

There is no reason why the weighting parameter c should be different on the bid and the ask side. The average inventory component for best ask (bid) will be positive (negative), since market participants with a positive (negative) inventory offer more competitive ask (bid) prices, following the theoretical considerations given in Section 2 and the Appendix[6]. However, as stated in the previous paragraph, the average inventory terms will not change over time and there is no reason why the mean of the inventory components should be different in absolute terms $\mid E(\bar{I}_{i,t}) \mid = \mid E(\bar{I}_{j,t}) \mid$, so both terms can be treated as constant. The equilibrium price assumed by market participants will be structurally lower on the ask side and higher on the bid side[7]. It is possible that the average belief changes over time, especially surrounding announcements. But there is no reason why the difference between

[5]This is not the case if one uses the last prices of one-minute or five-minute frequency, as occurs in some studies.

[6]See also Hansch et al. (1998) for empirical evidence that market participants with the most unfavorable inventory positions tend to pose the most competitive price.

[7]This can be seen graphically in Figure 2 in the Appendix, where a deeper insight is provided for the interested reader.

the average ask-side equilibrium price and the bid-side equilibrium price should change over time, so it is expected to be constant. Average order processing costs on the bid and ask sides should not be different ($\bar{T}_i = \bar{T}_j$), and can also be assumed to be constant [8].
The average asymmetric information component should normally be the same for the bid and ask sides. From the above reasoning, taking the expectation yields the following expression:

$$E(\bar{S}_t^*) = ((\bar{P}_{i,t}^* - \bar{P}_{j,t}^*) + \bar{T} - 2\bar{c}_2\bar{I}) + (2\bar{c}_1\bar{A}_t) \tag{8}$$

The equation has collapsed to a constant part, given in the first bracket, and the asymmetric information part, given in the last bracket. Here, we have already taken the expectation E for the spread equation. Inserting the average asymmetric information component and including the trade volume $\bar{V}_t$ and the numbers of trade per minute $\bar{N}_t$ yields:

$$E(\bar{S}_t^*) = ((\bar{P}_{i,t}^* - \bar{P}_{j,t}^*) + \bar{T} - 2\bar{c}_2\bar{I}) + (2\bar{c}_1\bar{c}_3\bar{D}_t + 2\bar{c}_1\bar{c}_4\bar{V}_t + 2\bar{c}_1\bar{c}_5\bar{N}_t) \tag{9}$$

As briefly discussed earlier, the trade volume (measured in ten thousand stocks) $\bar{V}_t$ and the number of trades per minute $\bar{N}_t$ serve as additional variables which can contain information about informed trading. Easley et al. (1996) state that there is a higher probability of informed trading in stocks with low trading volumes, so we include the number of trades per minute to account for these effects. On the other hand, large block trades seem to be related to adjustments due to new information, so we include the number of shares traded per minute in our setup[9]. Following this, we assume that numbers of trades and trade volume have a negative and positive impact, respectively, on the spread size. In addition, including these variables accounts for any potential information loss due to the aggregation to minute-frequency. In a stochastic estimation form, using K for all constant terms, this becomes:

[8] Here it is sufficient that the order-processing cost component does not change over the one-and-a-half-hour period under consideration- a fairly reasonable assumption.
[9] See also Glosten and Harris (1988) and Easley and O'Hara (1992) for further discussions and applications of these variables.

$$\hat{S}_t^* = \alpha_1 K + \alpha_2 D_t + \alpha_3 V_t + \alpha_4 N_t + \varepsilon_t \tag{10}$$

Using the spread series of different stocks, one can perform a pooled OLS regression to obtain information about the driving factors behind the spread. Compared with stock-individual regressions, which are used in many event-type studies, the pooled regression has the advantage that we have enough degrees of freedom to include a dummy variable for every minute under investigation. So we can see if there are any spread changes that are not explained by the other variables for the whole investigation period rather than for only the time surrounding the announcement. One disadvantage of the pooled OLS is the assumption of cross-sectionally common reaction coefficients for all stocks. To minimize the effect of this, we include a specific dummy variable for each stock to account for a stock-specific constant in the spread, denoted by Z. Additionally, we use only common stocks in one pooled regression in the sense that they are from the same country, frequently traded and all blue chips. This leads to considerably homogeneous sets of regression entries. Finally, the trade volume and numbersof trades included are not merely part of the asymmetric information term but also have the advantage that they account for stock-specific relevance. The estimation function containing all the explained variables is written in the usual matrix notation below:

$$S = [K\ D\ V\ N\ Z]\alpha + \varepsilon \tag{11}$$

In addition to the stock-specific dummy-variables, matrix Z also contains some dummy variables to control for extreme outliers. However, at most we had to control for twelve outliers in one of the FTSE estimations, a considerably small number in estimations with over eight thousand observations.

It is obvious that the empirical setup at this point fully reflects the theoretical background explained in Section 2, augmented with variables that control for stock-specific effects. To account for potentially influential effects that should be controlled for in the estimation, we define additional specifications.

Modification 1, APPC: Price volatility as measured by the absolute percentage price change per minute is also included as an explanatory variable. If the price is more volatile, the risk of large price changes due to large revaluations after informed trades rises, so it might be seen as an additional variable of the asymmetric information component.

Modification 2, QPPC: The quadratic percentage price change to the minute before was added as an explanatory variable to the general model specification. This serves as an alternative price volatility variable in which stronger price changes have a higher weight than in the first modification.

All estimations were conducted using White standard errors, which are robust against heteroscedasticity.

As robustness checks we also estimated a modification using GARCH(1,1) conditional volatility estimates as a variable measuring volatility. In addition, we estimated all setups including an AR(1) term to account for possible autocorrelation. The potential weakness of using a lagged dependent variable in a pooled OLS framework calls for a cautious interpretation of the results obtained from the same, which merely serve as an indicator exercise on possible neglected effects. Lyons et al. (1995) state that larger spreads due to new information in the market stay higher for a specific time horizon. This is expected to be caused by different market participants' beliefs concerning the impact on prices. So it is reasonable to assume that asymmetric information stays in the market for some time and gives us a reason to check for autocorrelated structures. Finally, we re-estimated our setups using Newey-West standard errors to account for heteroscedasticity and autocorrelation.

3.2. Data and Announcements

Data used for the empirical investigation was drawn from Bloomberg. It contains information about the best bid and ask as well as on the volumes and prices of trades for different stocks from various European countries at transaction frequency. This gives the full set

of information in contrast to often-used five-minute data. Data available for this analysis includes the dates of interest rate decisions by the ECB starting in July 2012 and ending in May 2013. During this time the ECB announced two interest rate cuts. Bloomberg has the data available with a history of about six months.

One very important date in this sample is September 6th, 2012. On that day at 13:45 CET the ECB made an interest rate announcement, in which it stated that it would keep interest rates unchanged. However, at the press conference forty five minutes later, Mario Draghi declared: "... It is against this background that the Governing Council today decided on the modalities for undertaking Outright Monetary Transactions [OMTs - ed.] in secondary markets for sovereign bonds in the Euro area. As we said a month ago, we need to be in the position to safeguard the monetary policy transmission mechanism in all countries of the Euro area, ... , and the Euro is irreversible" (Draghi, 2012). Furthermore, it is stated in the separate press release that "No ex ante quantitative limits are set on the size of Outright Monetary Transactions" (ECB 2012). So the ECB made two very important announcements that day, one concerning the interest rates and one concerning the unbounded program for buying sovereign bonds. This information is important for financial markets especially during the ongoing financial crisis in Europe.

We used several other dates for counterfactual exercises to check whether results are due to normal daytime properties of the spreads rather than announcement effects. These are dates that are chosen to be (i) days before and after announcement days, or (ii) matching weekdays in the week before and after. For the sake of brevity, all except one example are reported in the Appendix.

The spread used in this study was calculated by subtracting the latest best bid price from the transaction price if the transaction price was equal to or higher than the latest best ask price (transaction at the ask), or by subtracting the transaction price from the latest best ask price if the transaction price was equal to or lower than the latest best bid price

(transaction at the bid). Afterwards, the spread was divided by the mid-price between the transaction price and the latest best bid (ask) to make the results comparable for different stocks.

Finally the transaction-based data was aggregated to minute-frequency, as explained in the methodology sections. Minutes with no trade have been excluded. The resulting series are called the relative realized spread ($\bar{S}_t^r$) and give the costs for a potential round trip relative to the share midprice during the respective minute. The usual time for the ECB interest rate decision disclosure is 13:45 and the press conference usually starts at 14:30[10]. ECB announcements are always on Thursdays in our sample. If there is an influence of macroeconomic announcements by the ECB on prices and spreads, one should observe changes in the data around this time (Ederington and Lee (1993)). Table 1 gives an overview of the different dates used in the empirical investigation. Data of the stocks from the German DAX 30, the French CAC 40 and the British FTSE 100 Index have been used, the latter serving for comparative analysis as the stocks from the United Kingdom should be less sensitive than Euro-area stocks. Additionally, the days under consideration have all been checked for other important macroeconomic announcements using the Financial Times Economic Calendar. The most important control announcement for this study seems to be the US initial jobless claim numbers from the US Department of Labor, because these are usually released every Thursday at 8:30 EST (14:30 CET) i.e. the usual time of the ECB press conference.

4. Results

In the following we provide our empirical results. At the beginning of every subsection, the respective figures show the relative realized spreads over time, measured as the average

[10]The time used in this study is either Central European Time or Central European Summer Time, when no other time zones are explicitly mentioned.

Table 1: Date-overview

Date (all Thursdays)	Time	Kind
July 5th, 2012	13:45	Interest rate announcement (cut)
July 5th, 2012	14:30	Press conference
August 30th, 2012	13:45	No announcement
August 30th, 2012	14:30	No announcement
September 6th, 2012	13:45	Interest rate announcement (no change)
September 6th, 2012	14:30	Press conference and OMT announcement
October 4th, 2012	13:45	Interest rate announcement (no change)
October 4th, 2012	14:30	Press conference
November 8th, 2012	13:45	Interest rate announcement (no change)
November 8th, 2012	14:30	Press conference
December 6th, 2012	13:45	Interest rate announcement (no change)
December 6th, 2012	14:30	Press conference
January 10th, 2013	13:45	Interest rate announcement (no change)
January 10th, 2013	14:30	Press conference
February 7th, 2013	13:45	Interest rate announcement (no change)
February 7th, 2013	14:30	Press conference
March 7th, 2013	13:45	Interest rate announcement (no change)
March 7th, 2013	14:30	Press conference
April 4th, 2013	13:45	Interest rate announcement (no change)
April 4th, 2013	14:30	Press conference
May 2nd, 2013	13:45	Interest rate announcement (cut)
May 2nd, 2013	14:30	Press conference

This table shows the ECB announcements on the dates under consideration.

of the individual spreads of the stocks of each included country. The first figure always shows the spreads on days with important announcements i.e. the two interest rate cuts in our sample and the OMT announcement. It also shows the spread on the example comparison date August 30th, 2012. This date was the same weekday as of the crucial announcement on September 6th of the following week. For that day, data of the same daytime was used to check whether the findings were simply due to time properties of stock markets, as is reported in many studies (for example, Admati and Pfleiderer (1989), Foster and Viswanathan (1993) or Hartmann et al. (2001)). The second figure shows the spread of the other ECB announcement days with no interest rate changes.

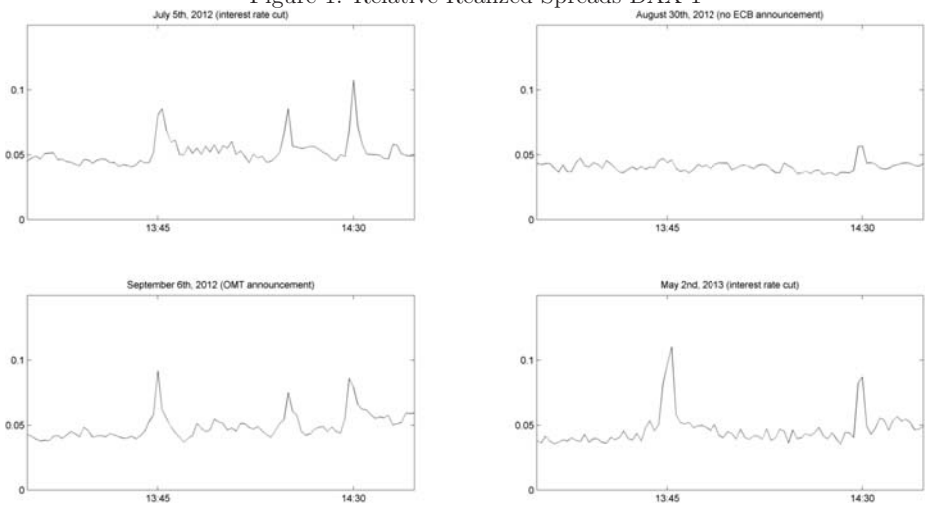
The tables then show the estimation results. Spreads were used in percent, the volume was measured in 10,000 shares, and the change in price was used in normal numbers.

4.1. DAX

In Figure 1, showing the relative realized spreads for the DAX stocks on important dates, one can observe strong increases in spread during the times of the ECB interest rate announcements and the corresponding press conferences. The data for August 30th, 2012 does not show this strong pattern, which can be seen as first evidence of an announcement effect. The slight increase around 14:30 might be explained by the US initial jobless claim numbers, released by the US Department of Labor. The spread increase at 14:15 on September 6th, 2012 and July 5th, 2012 can be explained by the disclosure of the ADP Employment Survey at this time.

Figure 2 shows the spreads on other interest rate announcement days. Here one can observe a slight increase in spreads surrounding 13:45 and 14:15 but the increase is much smaller than during days with interest rate changes or other important ECB news. On these days it is hard to tell whether the spread increase around 14:30 is due to the ECB press conference or mainly driven by the US jobless claims. Since this applies only to the 14:30 observations,

Figure 1: Relative Realized Spreads DAX 1



The figure shows the relative realized spread during the daytime and days under consideration averaged over all DAX stocks.

while effects are seen for both points of the daytime, the ECB interest rate announcements are supposed to be the driver. Notably, even if the US announcements were as influential as the domestic ones, this would not take away from the analysis on theoretical grounds regarding the pricing and information effects, as will be discussed later. Table 2 shows the most important estimation results for the DAX estimations and corresponds to Figure 1. Full result tables are available on request.

The results concerning the two announcement dates with a rate change (July 5th, 2012 and May 2nd, 2013) and the day of the Draghi speech (September 6th, 2012) show constant terms of 0.036% to 0.057%. This means that the basis spread for the DAX stocks lies on average around 0.05% of the current stock price. Of course, the basis spread is slightly different for the individual stocks, which is captured by the coefficients of the stock dummy variables which are almost all highly significant (not shown here, forconsiderations of space).

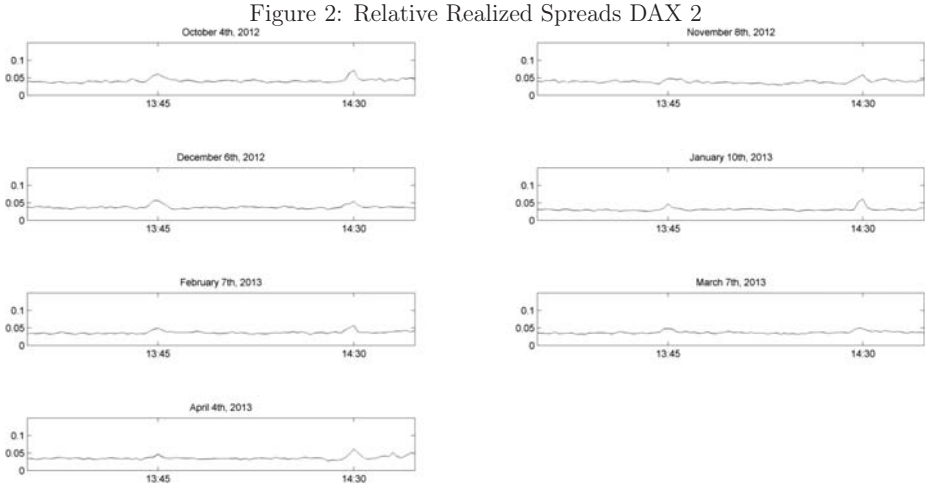
Estimated coefficients for trade numbers are mostly significant and then show the expected signs: an increase in the number of trades by 100 reduced the spread size by about 0.01

Table 2: Estimation Results DAX

Date	July 5th, 2012 (interest rate cut)			August 30th, 2012 (no announce.)			September 6th, 2012 (OMT)			May 2nd, 2013 (interest rate cut)		
Variable	General	Modif. 1	Modif. 2	General	Modif. 1	Modif. 2	General	Modif. 1	Modif. 2	General	Modif. 1	Modif. 2
Constant	0.0522***	0.0569***	0.0568***	0.0546***	0.0493***	0.0499***	0.0513***	0.0487***	0.0497***	0.04***	0.0369***	0.038***
	18.4787	18.6007	18.859	15.6436	17.1531	16.7826	14.1448	15.2525	15.6389	19.6791	16.4289	17.2648
Traden.	-0.0001***	-0.0001***	-0.0001***	-0.0001	-0.0001**	-0.0001**	-0.0002***	-0.0002***	-0.0002***	-0.0001***	-0.0001***	-0.0001***
	-4.7438	-5.3516	-5.5797	-1.3861	-2.552	-2.5196	-5.9442	-5.8423	-5.7354	-2.6463	-2.6888	-2.6106
Volume	0.0001	0.0001	0.0001	-0.0001	0.0005	0.0005	-0.0001	-0.0002	-0.0002	0.0003	0.0003	0.0003
	1.0706	1.0208	0.7264	-0.0881	1.097	1.1271	-0.6893	-0.8716	-0.8614	0.9489	0.7553	0.761
APPC		0.0036			0.0496***			0.0355***			0.0326***	
		0.6039			4.1153			3.9129			4.0732	
QPPC			3.344*			36.3261***			10.4372***			9.1944***
			1.7034			2.651			2.9499			3.4645
13:43	0.0001	-0.0046	-0.0046	-0.0022	0.0016	0.0019	0.0145***	0.0154***	0.0156***	0.0124***	0.0143***	0.0144***
	0.045	-1.437	-1.4348	-0.5585	0.4918	0.555	3.0057	3.43	3.4721	4.3906	4.842	4.8765
13:44	0.0104***	0.0054	0.0055	-0.0025	0.0004	0.001	0.0147***	0.0153***	0.0157***	0.0418***	0.0402***	0.0406***
	3.0075	1.4911	1.5169	-0.6926	0.1454	0.3372	3.1206	3.4634	3.5592	8.1976	9.1921	9.1067
13:45	0.0427***	0.037***	0.0368***	-0.006	-0.0022	-0.0019	0.0559***	0.0538***	0.0552***	0.0617***	0.059***	0.0598***
	10.4493	8.8093	8.8099	-1.5429	-0.6488	-0.5554	10.3582	10.4951	10.7999	13.0157	14.8365	15.0887
13:46	0.0497***	0.0401***	0.0388***	0.0016	0.0051	0.0056	0.0149***	0.0149***	0.0156***	0.0742***	0.0676***	0.0686***
	8.0796	8.0232	7.5457	0.2979	1.0582	1.1345	3.3512	3.578	3.7875	12.0586	12.3336	12.6513
13:47	0.0286***	0.0231***	0.023***	-0.0076*	-0.0044	-0.0039	0.0077	0.0083*	0.0088*	0.0205***	0.0177***	0.0188***
	7.9609	6.1015	6.127	-1.9171	-1.2431	-1.0794	1.5857	1.7791	1.9177	5.6174	5.429	5.9345
14:28	0.0056	0.0008	0.0009	-0.0076**	-0.0039	-0.0034	0.0143***	0.0149***	0.0153***	0.0018	0.0039	0.0037
	1.6376	0.2334	0.2409	-2.171	-1.3198	-1.1324	3.0106	3.3657	3.4556	0.5488	1.1703	1.0978
14:29	0.0254***	0.0178***	0.0178***	0.0102**	0.0134***	0.014***	0.0491***	0.0487***	0.0496***	0.0224***	0.0242***	0.0242***
	4.9694	3.9016	3.9016	2.0705	3.0049	3.108	9.395	9.7473	10.0087	5.8122	6.1364	6.1563
14:30	0.0557***	0.0476***	0.0476***	0.014**	0.0118***	0.0125***	0.0411***	0.0416***	0.0421***	0.0411***	0.0425***	0.0426***
	8.6301	8.0101	8.0364	2.5223	3.0225	3.1632	8.6402	9.3354	9.4726	7.3073	7.7085	7.5975
14:31	0.0284***	0.0207***	0.0206***	-0.0017	0.0011	0.0014	0.0299***	0.0292***	0.0301***	0.0109***	0.0121***	0.0124***
	5.1886	4.131	4.1189	-0.4331	0.319	0.3719	7.3551	7.7841	8.1213	3.5974	3.7951	3.9395
14:32	0.0158***	0.0108***	0.0107**	-0.0043	-0.0012	-0.0007	0.029***	0.0245***	0.0252***	0.0049**	0.0071***	0.0068***
	3.9015	2.5467	2.5315	-1.2307	-0.3951	-0.2215	6.9321	5.8525	5.9018	2.0047	2.7511	2.6617
R-Sqr	0.6655	0.6966	0.697	0.5989	0.633	0.6318	0.6603	0.6648	0.6634	0.7382	0.7592	0.7582

The table shows the estimation results (coefficients and t-statistics) for certain dates for the DAX stocks. The specifications correspond to the respective model setups explained in the text. *,** and *** indicate significance on the 10%, 5% and 1% level. The lower 10 variables correspond to the dummy variables for the respective one minute interval following the stated daytime.

Figure 2: Relative Realized Spreads DAX 2



The figure shows the relative realized spread during the daytime and days under consideration averaged over all DAX stocks.

percentage points on July 5th, 2012, for example. The trade volume seems to play no role, since none of the coefficients here is statistically significant.

A huge effect of the announcements is observed which cannot be captured either by the volume, the number of trades, the volatility, or the price change. This is evident from the highly significant dummy variables for the relevant minutes. The sharp rise in spread begins shortly before the interest announcement or at the time of the announcement, depending on which specification is under consideration, and the announcement effect net of the other explanatory variables amounts to over 65% of the basis spread on July 5th, 2012. We can observe the same pattern for the time shortly before the press conference on that day, and here the spread rises even more: the announcement effect amounts to over 80% of the basis spread. Both of the other days with important announcements show similar patterns, with the effect surrounding the 13:45 announcement being even stronger (over 100% above the basis spread).

The comparison with August 30th, 2012 shows that, interestingly, the time dummy variables around 14:30 show significant positive impacts, but with much smaller impacts and a lower

number of significant dummies. It turns out that the above-mentioned US Department of Labor announcement indeed has an effect on the spreads, although this seems to be much smaller than the effect of the ECB press conference on the other dates.

Regarding the extension using the absolute percentage price change (APPC) and the quadratic percentage price change (QPPC), the results are straightforward: with the exception of Modification 1 for 5th July, all estimations reveal a significant and positive impact, which is in line with previous studies reporting a positive effect of volatility on spreads (see, for example, Bollerslev and Melvin (1994)).

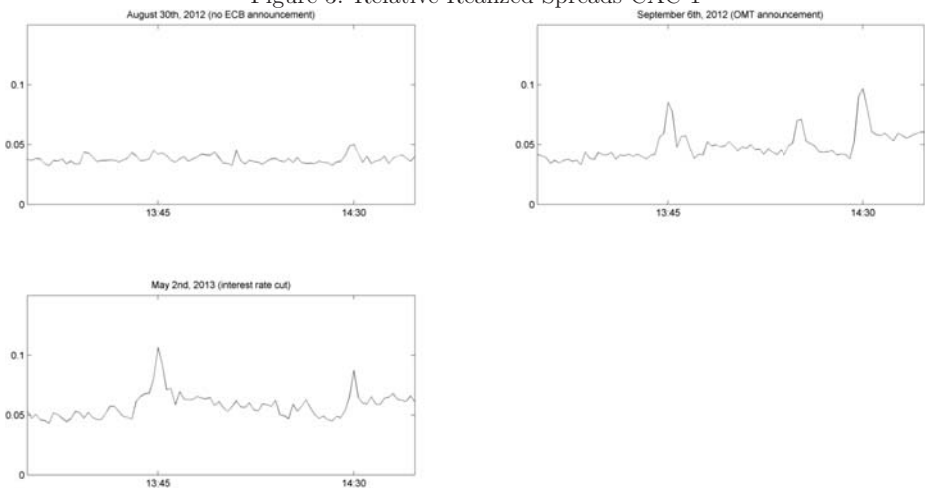
Regarding Modification 1, a price increase of one percent leads to a spread increase of between 0.032 and 0.05 percentage points where significant.

It is good news for the model that all explanatory variables remain significant and are robust to changes in specifications. All the robustness checks mentioned above were conducted and support the results described in this section. In addition, another specification excluding the stock individual dummy variables was conducted, leading to a much stronger negative impact of the number of trades and a significant and positive impact of trade volume on spreads. This leads to the conclusion that trade volume and numbers of trades are in line with the former theoretical considerations, although rather in a longer-termed sense, implying that stocks with higher numbers of trades and lower trade volumes have a structurally lower spread. Further results for counterfactual dates are supplied in the Appendix. It turned out that the time around 14:30 was often characterized by higher spreads. However this is just the case if major US macroeconomic announcements are released at this time.

4.2. CAC

Following the results for Germany, those for French stocks of the CAC 40 are reported. Unfortunately, no data was available for July 5th, 2012, leading to the omission of that one day as compared to the German sample, using DAX stocks. Again, increases in the realized

Figure 3: Relative Realized Spreads CAC 1



The figure shows the relative realized spread during the daytime and days under consideration averaged over all CAC stocks.

spread can be observed, with the effects around the announcement times on the important days being much stronger than on other days. Table 3 shows the relevant estimation results for the CAC stocks.

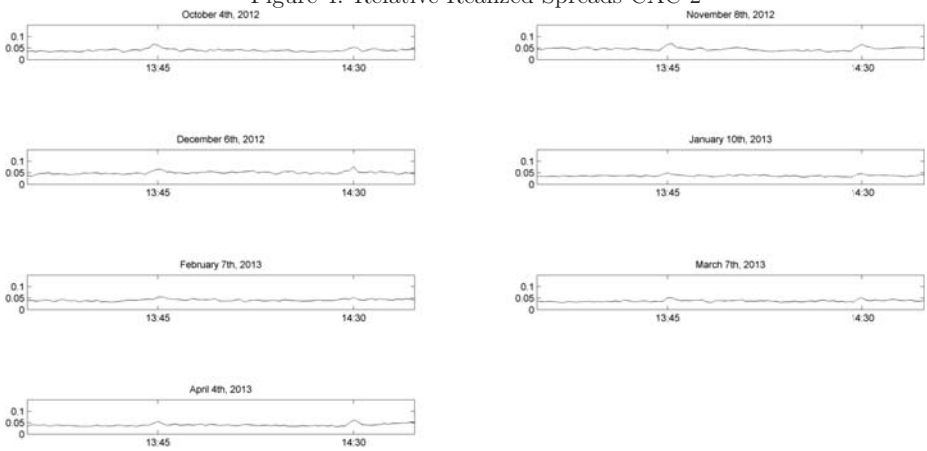
Estimated constant terms are quite similar to the DAX constants and the basis spread amounts to between 0.035% and 0.065% of the relevant stock price. In contrast to the results for DAX stocks, the trade number plays no significant role in the formation of the spreads. Trade volume is again insignificant in most specifications except for estimations for May 2nd, 2013. Here, the estimations reveal a negative impact of trade volume on spreads, at least on the 5% significance level, which is in contrast to theoretical considerations. However, the impact is quite low, since trade volume is measured in 10,000 trades. Following the results, a trade of 10,000 shares leads to a decrease in spreads of about 0.0006 percentage points. Furthermore, omitting the stock-specific dummy variables again alters the results, as in the case of the DAX estimations: the number of trades becomes statistically highly significant and negative, while the trade volume coefficient stays either insignificant or is

Table 3: Estimation Results CAC

Date	August 30th, 2012 (no announce.)			September 6th, 2012 (OMT)			May 2nd, 2013 (interest rate cut)		
Variable	General	Modif. 1	Modif. 2	General	Modif. 1	Modif. 2	General	Modif. 1	Modif. 2
Constant	0.0434**	0.0454***	0.0462***	0.0423***	0.0356***	0.0363***	0.0642***	0.0568***	0.0574**
	11.9869	15.6433	15.9173	12.7363	12.4549	12.6066	20.5283	17.7577	18.0385
Traden.	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	-0.6499	-0.8642	-0.7292	-1.2102	-1.3244	-1.3124	0.8041	0.3958	0.5225
Volume	-0.0002	-0.0003	-0.0003	0.0000	-0.0001	-0.0001	-0.0005**	-0.0006**	-0.0006**
	-0.4646	-0.6648	-0.6522	0.0018	-0.3843	-0.4508	-2.0707	-2.3625	-2.3204
APPC		0.0499***			0.0295***			0.0218***	
		4.8895			3.8904			3.5018	
QPPC			25.8817***			8.5275***			4.7899**
			3.5683			3.0476			2.2211
13:43	0.0008	0.0043	0.0048	0.0149***	0.0208***	0.0208***	0.0125***	0.0188***	0.0191***
	0.2154	1.2884	1.4393	3.851	6.0279	6.0081	2.7971	4.1693	4.2483
13:44	0.0076*	0.0076**	0.0082***	0.0183***	0.0238***	0.0241***	0.0274***	0.0337***	0.0341***
	1.8316	2.3936	2.5948	5.0039	7.3173	7.3823	5.9131	7.2801	7.3178
13:45	0.0004	0.0048	0.0052	0.0447***	0.0472***	0.0488***	0.0546***	0.0593***	0.0603***
	0.0991	1.4235	1.5577	9.8508	11.2208	11.7235	13.6314	14.4963	14.8258
13:46	0.0016	0.0053*	0.0056*	0.0306***	0.0345***	0.0357***	0.0411***	0.0459***	0.0469***
	0.4515	1.6994	1.7736	7.3599	9.1252	9.4631	11.8494	12.8	13.1361
13:47	-0.0012	0.0025	0.0028	0.0088**	0.0129***	0.0139***	0.0172***	0.0229***	0.0236***
	-0.2868	0.7007	0.7735	2.0441	3.2239	3.4902	4.0765	5.4219	5.6043
14:28	-0.0003	0.0039	0.0043	0.0127***	0.0171***	0.018***	0.0017	0.0084*	0.0085*
	-0.0803	1.2137	1.3284	3.4382	5.3277	5.576	0.3578	1.7296	1.7426
14:29	0.0118**	0.0144***	0.0149***	0.0499***	0.0536***	0.0548***	0.0072	0.0138***	0.0139***
	2.3642	3.0912	3.1751	11.554	13.2753	13.6781	1.6167	3.123	3.133
14:30	0.0108**	0.0125***	0.013***	0.0539***	0.0587***	0.0594***	0.0326***	0.0392***	0.0394***
	2.4068	3.3028	3.4169	11.4508	13.4738	13.6355	5.7477	6.9089	6.9324
14:31	0.0001	0.0031	0.0036	0.0376***	0.0413***	0.0425***	0.0111***	0.0172***	0.0177***
	0.0204	0.9787	1.1462	9.7655	11.5872	12.0957	2.8587	4.3689	4.4907
14:32	-0.0052	-0.0021	-0.0017	0.0214***	0.0208***	0.0211***	0.0053	0.0119***	0.0121***
	-1.4153	-0.6779	-0.5426	5.7583	5.6098	5.5276	1.3286	2.9682	3.0262
R-Sqr	0.4752	0.5019	0.4993	0.5662	0.5745	0.5733	0.5825	0.5914	0.5903

The table shows the estimation results for certain dates for the CAC stocks. The specifications correspond to the respective model setups explained in the text. *,** and *** indicate significance on the 10%, 5% and 1% level. The lower 10 variables correspond to the dummy variables for the respective one minute interval following the stated daytime.

Figure 4: Relative Realized Spreads CAC 2



The figure shows the relative realized spread during the daytime and days under consideration averaged over all CAC stocks.

positively significant. Price volatility is highly significant and shows the expected sign in all specifications, regardless of whether it is measured as APPC or QPPC.

As in the DAX case, the time dummy variables are highly significant and, compared with the basis spread, quite large at times of important decisions, which was already apparent in the figures. For example, the time around the press conference on September 6th, 2012 is characterized by spreads that are up to 150% higher than the basis spread. Again, the estimations for August 30th, 2012 show some increase in spreads during the time under consideration but these are much smaller and do not stay high as long as on days with important announcements. All formerly mentioned robustness checks were conducted and support the findings given here. The findings of the counterfactual estimations correspond to the DAX results.

4.3. FTSE

Having found evidence of positive impacts of the ECB announcements on spreads in two major Eurozone countries, we turn to the FTSE 100 index for United Kingdom stocks.

Since Great Britain is not a member of the Eurozone, one would expect that the impact of the ECB decisions would not be as strong for stocks of this index as for Eurozone stocks. However, ECB decisions and announcements should still have indirect impacts on companies from other currency areas, especially within Europe, albeit on a smaller scale.

Data was not available for all dates, but the remaining dates for which the realized spread is depicted in the next figures indeed show some spread increases during announcement periods, which supports the findings of previous sections. As can be seen from the first figure on the date of the OMT announcement (September 6th, 2012), and in particular on the date of the interest rate cut (May 2nd, 2012), the spread increases around the announcement time of 13:45. This is not the case on the date with no announcement or on other dates where the ECB announced it would hold interest rates constant. Still, around the press conference time of 14:30 the spread increases more strongly than during the same time on August 30th, 2012. Graphical inspections indicate results in line with the observations above, where increases in spreads can be observed even when announcements are made elsewhere, although with lesser impact.

Table 4 shows the estimation results for the FTSE stocks. The basis spread lies between 0.049% and 0.092% of the relevant stock price. The results for trade volume and numbers of trades are ambiguous. Trade volume is significant only in some specifications and shows a negative sign. Number of trades is also not always significant and has changing signs. This is in contrast to both theoretical considerations and the findings for the DAX stocks. However, the coefficients are again quite small, and excluding the stock-specific dummies changes the results at least for the numbers of trades.

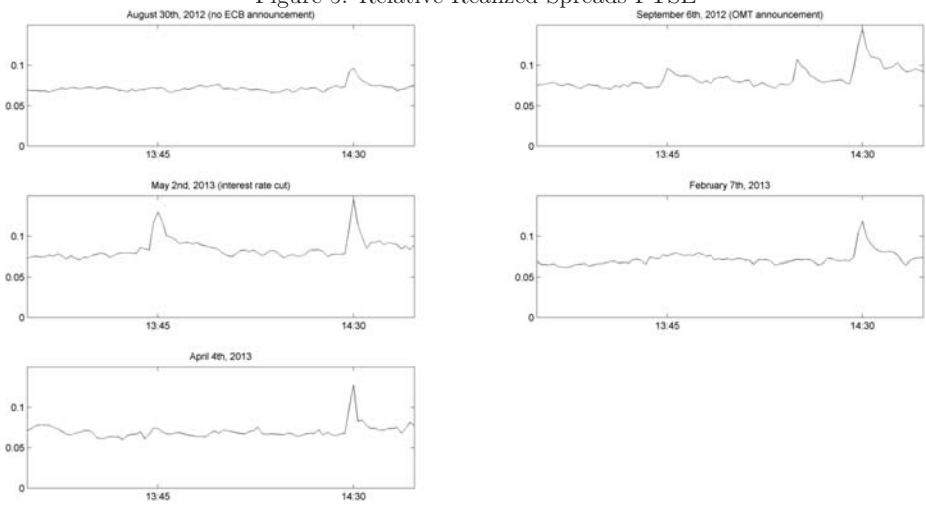
The number of trades coefficient becomes negative and highly significant for all dates. The trade volume coefficient stays negative but insignificant in most cases. Only on May 2nd, 2013 do the estimations show a significantly negative influence of the trade volume on spreads. The coefficients describing the volatility of the stock price are in every specification highly

Table 4: Estimation Results FTSE

Date	August 30th, 2012 (no announce.)			September 6th, 2012 (OMT)			May 2nd, 2013 (interest rate cut)		
Variable	General	Modif. 1	Modif. 2	General	Modif. 1	Modif. 2	General	Modif. 1	Modif. 2
Constant	0.0757***	0.0772***	0.0785***	0.0912***	0.0764***	0.0783***	0.0858***	0.0492***	0.0516***
	14.8989	14.3516	14.5884	13.3195	12.3067	12.6537	14.5586	13.3143	13.6074
Traden.	0.0001***	0	0.0001	-0.0001**	-0.0001***	-0.0001***	0.0001***	0	0.0001*
	2.826	1.2778	1.576	-2.2269	-2.8771	-2.8885	3.5792	1.5394	1.8783
Volume	-0.0002	-0.0003*	-0.0003*	0	-0.0001	0	-0.0002***	-0.0001***	-0.0001***
	-1.3222	-1.9481	-1.9185	-0.4863	-1.1236	-0.6737	-3.0131	-2.4145	-2.355
APPC		0.1351***			0.0913***			0.1012***	
		10.717			7.166			10.6559	
QPPC			72.694***			30.7044***			29.2127***
			8.7134			3.2392			5.9737
13:43	0.0079*	0.0015	0.0034	0.0004	-0.0048	-0.0034	0.0084*	0.0056	0.007
	1.7326	0.3015	0.6841	0.0613	-0.9341	-0.6494	1.7466	1.2306	1.4975
13:44	0.0051	-0.0006	0.0013	0.0105*	0.005	0.007	0.0446***	0.0387***	0.041***
	1.3353	-0.1271	0.2935	1.8997	1.019	1.438	8.6281	7.7936	8.1699
13:45	0.0025	-0.0044	-0.0022	0.0246***	0.0142***	0.0179***	0.0549***	0.0477***	0.0497***
	0.6106	-0.95	-0.48	4.6575	2.9789	3.6563	9.4493	8.3532	8.8017
13:46	0.0091**	0.0024	0.0039	0.0182***	0.0091*	0.0127**	0.0412***	0.0346***	0.0375***
	2.0249	0.4747	0.7989	3.1092	1.7102	2.391	8.4671	7.1248	7.7758
13:47	-0.0016	-0.007	-0.0055	0.0082	0.0013	0.0043	0.02***	0.0137***	0.0163***
	-0.3661	-1.4085	-1.1262	1.4186	0.2525	0.8388	3.9617	2.7344	3.2323
14:28	0.0069	-0.0008	0.001	0.0225***	0.0159***	0.0185***	0.0074*	0.0028	0.0043
	1.5749	-0.1662	0.2096	3.8041	3.0152	3.4886	1.6873	0.6423	0.9877
14:29	0.0253***	0.0169***	0.019***	0.0492***	0.0402***	0.0437***	0.0342***	0.0274***	0.0296***
	5.3577	3.2773	3.7229	8.2255	7.4899	8.0095	7.2329	6.0785	6.5148
14:30	0.026***	0.0153***	0.0175***	0.0601***	0.0481***	0.051***	0.0698***	0.0631***	0.0657***
	4.6186	2.6655	3.095	8.1475	7.9116	8.4309	10.0981	9.3641	9.6553
14:31	0.0135**	0.0047	0.006	0.0393***	0.0313***	0.0343***	0.0238***	0.0176***	0.0201***
	2.4995	0.8708	1.1307	6.0497	5.244	5.7652	4.8573	3.5914	4.1029
14:32	0.0065	-0.001	0.0013	0.0381***	0.0226***	0.0266***	0.0101**	0.005	0.0066
	1.4243	-0.2079	0.2572	6.008	3.7571	4.1433	2.143	1.0324	1.375
R-Sqr	0.6742	0.6965	0.6951	0.6726	0.6881	0.6867	0.659	0.6778	0.6759

The table shows the estimation results for certain dates for the FTSE stocks. The specifications correspond to the respective model setups explained in the text. *,** and *** indicate significance on the 10%, 5% and 1% level. The lower 10 variables correspond to the dummy variables for the respective one minute interval following the stated daytime.

Figure 5: Relative Realized Spreads FTSE



The figure shows the relative realized spread during the daytime and days under consideration averaged over all FTSE stocks.

significant and show the expected sign. For August 30th, 2012 we see an increase in spreads around 14:30. This is common to all three European stock markets under investigation in this study and, as mentioned, may be attributed to the release of the US jobless claim numbers. Surrounding the OMT release on September 6th, 2012 (interest rate cut on May 2nd, 2012), we can observe a strong increase in spreads of about 64% (up to 100%) of the basis spread. Comparing the spread increase around the press conference during these days with those of the comparison date shows that it is much larger, implying that the ECB announcement is of higher impact for UK stocks than the US announcement. From the authors' point of view, this is in line both with what to expect and with the results for Eurozone stocks above.
Again, all robustness checks using heteroscedasticity and autocorrelation-consistent standard errors further strengthen our view of the reliability of the estimations and the results.
The findings of the conducted counter factual estimations correspond to the DAX and CAC results.

5. Discussion

The empirical findings clearly show that ECB announcements have an influence on European stock spreads. Spreads tend to rise shortly before announcements and return to their initial level shortly afterwards. Increases are stronger in Eurozone stocks than in non-Eurozone stocks, as checked by using FTSE stocks in the analysis. This is perfectly in line with theoretical considerations, since one can assume that the importance of ECB decisions is higher for Eurozone stocks, but is still relevant to other European stock markets - especially when close trading partners such as the UK are considered.

The theoretical framework that serves as a baseline for the study, makes clear that the observable rises in spread must come from the asymmetric information component. As spreads rise strongly in line with announcements that are important for price changes in stocks, market-makers and brokers apparently widen the spreads to compensate for potential losses incurred from the exploitation of information by traders. Even when controlling for other variables which may drive spreads, the increase in spreads is huge and so the spread is occasionally twice as high as half an hour earlier when changes in interest rates are announced. This also holds true for the influential Draghi speech on OMT. On days with ECB announcements where no interest rate changes were made, the spread increased much less; and for FTSE stocks it seems that there were no effects at all on those days.

Interestingly, surveys regularly carried out by Bloomberg before interest rate announcements reveal that the ECB decisions to keep the interest rates unchanged on those days were expected by most market observers[11]. Accordingly, there was probably less uncertainty about the fundamental value of the stocks in the market. The interest rate cut on July 5th, 2012 was also expected by many market observers (Black and Randow (2012)), but this was the

[11]See internet resources for Bloomberg News survey results concerning the ECB decision forecasts, for example Black and Thesing (2012), Bloomberg.com (2012), Riecher (2012), Black and Thesing (2013), Riecher (2013).

first time that the main refinancing rate was lowered below 1%. Additionally, a change in a crucial variable like the interest rate can also cause uncertainty about the fundamental value, even though it was expected. The decision on September 6th, 2012 not to change the rate, on the other hand, was not commonly anticipated before (Thesing (2012)). Furthermore, there was uncertainty about the OMT before the declaration.

This strengthens the view that asymmetric information induced by uncertainty about the fundamental value drives the spreads, as we can see in particular for September 6th, 2012, July 5th, 2012 and May 2nd, 2013.

These findings are in line with other studies concerning macroeconomic news such as those by Fleming and Remolona (1999) or Erenburg and Lasser (2009).

Certain US macro announcements also have huge impacts on the spreads of European stocks. This is apparently due to the importance of US economic indicators (such as the initial jobless claims), to the world economy and, by that, also to European stock markets. One can see these effects by looking at our results and the discussion in the previous section, but also by looking at the counterfactual results (result tables are supplied in the Appendix). Here we can observe huge spread increases, for example, on April 5th, 2013 surrounding 14:30CET, which is due to three major macroeconomic US data releases (unemployment numbers, trade balance, private payrolls). It has already been reported by Harju and Hussain (2011) that US macro announcements have a significant impact on prices and the volatility of European equity markets, and from our study it is evident that they also lead to spread increases.

Turning to the additional variables, we were able to observe a strong and significantly positive impact of volatility on spreads. As volatility is a measure of market uncertainty, these results further strengthen our theoretical considerations about the information component. The results concerning trading volume and numbers of trades are ambiguous at first glance because the coefficients are often insignificant or characterized by changing signs. However, if we omit the stock-specific dummy variables from our analysis the resulting coefficients

are as assumed, based on the theoretical framework. This leads to the interpretation that these variables can be used rather as stock-specific variables, measuring the longer-term characteristics of the stocks, than as reliable influence variables in high-frequency spread adjustments.

6. Concluding remarks

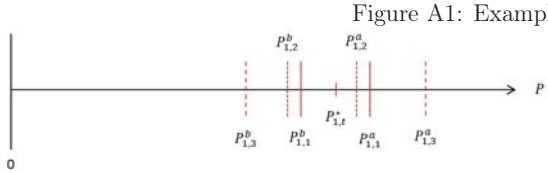
In this study we have analyzed the impact of ECB macro announcements on European blue chips. We find that there is a strong and highly significant impact of macro announcements on spread size, which is due to changes in asymmetric information in the market. In line with this, spread reactions are especially high around very important announcements, such as the Outright Monetary Transactions announcement, and around unexpected news. In addition, we have found that the reactions tend to be higher for Eurozone spreads than for British spreads, which is probably due to the varying importance of ECB announcements in these areas. Furthermore, major US macroeconomic announcements seem to have a strong impact on the spreads of European stocks.

Unfortunately, no data was available to test the impact of an ECB announcement concerning an increase in interest rates. Further research in this area is highly recommended to give more robustness to the findings and to investigate an interest rate increase announcement. It would also be interesting to check the reactions of the spreads of European stocks to announcements of other central banks and to further analyze the reactions to US news.

Appendix Model explanation and further discussion

If one is not considering a monopolistic dealer market, it is more appropriate to investigate the inside spread rather than the individual spread. The inside spread is the difference between the most competitive prices (the lowest ask price and the highest bid price) (Glosten (1987)). The reason for using the inside spread is that in most cases, for example in a limit order book market, the most competitive prices will usually not be set by the same market participants. So the inside spread is: $S_t^* = min(P_{1,t}^a, \ldots, P_{n,t}^a) - max(P_{1,t}^b, \ldots, P_{n,t}^b)$.
Figure 6 illustrates a stylized example for the monopolistic market.

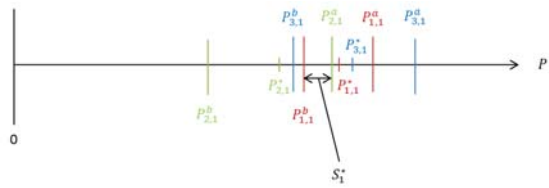
Figure A1: Example 1



P states the respective price. a denotes that it is an ask price, b that it is a bid price and$*$indicates the equilibrium price. t indicates the status as described in the text and the first sub index indicates the market participant which is always the same in Figure 1.

In a monopolistic dealer market, the spread would be the difference between the two prices shown by the red bars ($P_{1,1}^a - P_{1,1}^b$), assuming an initial inventory of 0. If his inventory position is positive (negative), for example after a buy (sell) in the first period, the dealer will lower (increase) both quotes in the second period (see Ho and Stoll (1981) and Ho and Macris (1984)). The spread is now $P_{1,2}^a - P_{1,2}^b$. If the market maker believes that he faces more (less) asymmetric information in the market, the spread will widen (narrow) ($P_{1,3}^a - P_{1,3}^b$), as is stated, for example, in Glosten and Harris (1988).
In a non-monopolistic market, one can draw a different picture. Figure 7 shows a stylized example of a non-monopolistic market in the sense that other participants are also acting as liquidity suppliers.

Figure A2: Example 2

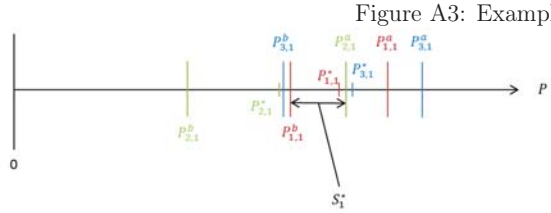


P states the respective price. a denotes that it is an ask price, b that it is a bid price and $*$ indicates the equilibrium price. t indicates the status as described in the text and the first sub index indicates the market participant. S^*_1 indicates the inside spread.

There will be no bid price higher than the lowest ask price and vice versa because any desire to trade at this condition would be directly executed. Here, the inside spread is $P^a_{2,1} - P^b_{1,1}$.

It is obvious that the probability of a smaller spread will increase with the number of market participants, so there can be a small spread even when the beliefs about the true value diverge and the asymmetric information in the market is high. But assuming all other variables are constant (especially the number of participants), an increase in asymmetric information in the market will lead to higher spreads. Figure 8 shows the same situation as in Figure 2, but with a higher asymmetric information belief for all participants.

Figure A3: Example 3



P states the respective price. a denotes that it is an ask price, b that it is a bid price and $*$ indicates the equilibrium price. t indicates the status as described in the text and the first sub index indicates the market participant.

Table 5: Control Results DAX General Model

Date (2013)	March 28th	April 3rd	April 5th	April 11th	April 25th	May 3rd	May 9th
Constant	0.0416***	0.0349***	0.0388***	0.0444***	0.0546***	0.0354***	0.0544***
	16.1968	17.4189	16.3068	14.7314	19.2833	17.7197	17.155
Traden.	0	-0.0001	0	-0.0001	-0.0001***	-0.0001***	-0.0001
	-0.5274	-1.3917	-0.4994	-1.4094	-2.8712	-3.9415	-1.2538
Volume	0.0005	0	-0.001*	0.0002	0.0005**	0.0002	0.0007
	1.0251	-0.029	-1.8725	0.4291	1.9517	0.9798	1.2758
13:43	0.0005	-0.0028	0.0022	-0.004	0.0007	0.0028	0.003
	0.1323	-1.1653	0.8936	-1.0444	0.1831	0.9303	0.9501
13:44	0.0038	0.0007	0.0039	-0.0071**	0.0017	0.0067**	-0.0025
	1.2253	0.267	1.329	-2.1803	0.6139	2.3404	-0.8305
13:45	0.0002	-0.0013	0.001	-0.007*	-0.0028	0.0023	-0.0005
	0.0659	-0.4749	0.3244	-1.7709	-1.1058	0.981	-0.1481
13:46	0.0003	0.0001	0.004	-0.0074**	0.0002	0.0037	0.003
	0.0861	0.0566	1.3319	-2.0775	0.0706	1.4295	0.7003
13:47	0.0003	0.0052*	0.0055**	-0.0068*	-0.0019	0.003	0.0031
	0.11	1.6699	2.0192	-1.7486	-0.7629	0.91	0.7798
14:28	0.0009	0.0035	0.0093***	-0.0085**	0.0013	0.01***	0.0054
	0.2783	1.251	3.4535	-2.4286	0.5011	2.6728	1.3718
14:29	0.0043	0.0019	0.0323***	0.0024	0.018***	0.0259***	0.0219***
	1.1492	0.5989	9.6968	0.6244	4.8969	6.9474	4.3819
14:30	0.0055**	0.0028	0.1649***	0.0212***	0.0315***	0.0898***	0.0359***
	2.0806	0.89	19.537	5.069	7.189	17.1768	6.5086
14:31	0.0004	0.0026	0.032***	0.0059	0.0161***	0.0409***	0.0093**
	0.1373	1.0033	7.4351	1.3343	5.377	11.9543	2.2025
14:32	-0.002	0.0035	0.0223***	-0.0041	0.0073***	0.0157***	0.0081**
	-0.6272	1.2348	5.6783	-1.2184	2.7619	5.2534	2.3438
R-Sqr	0.4859	0.5239	0.785	0.6042	0.612	0.7142	0.6043

The table shows the estimation results of the general model for certain controldates for the DAX stocks. *,** and *** indicate significance on the 10%, 5% and 1% level. The lower 10 variables correspond to the dummy variables for the respective one minute interval following the stated daytime.

Table 6: Control Results DAX Modification 1

Date (2013)	March 28th	April 3rd	April 5th	April 11th	April 25th	May 3rd	May 9th
Constant	0.0378***	0.0316***	0.0456***	0.0347***	0.0526***	0.0387***	0.053***
	16.6429	20.2619	19.2476	18.3375	19.8413	14.233	15.1831
Traden.	-0.0001	-0.0001**	-0.0002***	-0.0001**	-0.0001***	-0.0001***	-0.0002***
	-1.0459	-2.2601	-3.838	-2.3934	-3.8451	-4.1489	-2.8495
Volume	0.0004	0	-0.0006	0.0001	0.0004*	0.0002	0.0006
	0.8553	-0.019	-1.2485	0.4246	1.7324	1.2357	1.0827
APPC	0.0436***	0.0512***	0.0297***	0.0625***	0.0439***	0.026***	0.0909***
	4.3339	4.7084	3.3384	5.6744	5.0933	2.6939	6.4185
13:43	0.0029	-0.0011	-0.0047**	0.0043	0.0008	-0.0011	0.0006
	0.8524	-0.5477	-1.9987	1.4582	0.2013	-0.3102	0.1746
13:44	0.0066**	0.0029	-0.0032	0.0017	0.0014	0.0027	-0.0041
	2.3675	1.1825	-1.1227	0.7172	0.5543	0.8158	-1.2668
13:45	0.0022	0.0008	-0.0062**	0.0017	-0.0029	-0.0018	-0.0026
	0.756	0.3226	-2.0216	0.5526	-1.1796	-0.5919	-0.7563
13:46	0.003	0.0018	-0.0028	0.0011	0.0006	-0.0002	0.0006
	0.8826	0.8898	-0.9856	0.4228	0.2017	-0.0548	0.1271
13:47	0.0029	0.0073***	-0.0018	0.0017	-0.0017	-0.0007	-0.0027
	1.0193	2.6269	-0.6962	0.5843	-0.7007	-0.1875	-0.8394
14:28	0.0033	0.0049**	0.0028	0.0001	0.0015	0.0059	0.0044
	1.1658	2.0268	1.1047	0.0314	0.6392	1.4011	1.0791
14:29	0.0069**	0.0037	0.0263***	0.0111***	0.0178***	0.0218***	0.0203***
	2.0303	1.289	8.7187	3.7566	5.0423	5.2129	3.9095
14:30	0.0079***	0.005*	0.1572***	0.0283***	0.0314***	0.0806***	0.0286***
	3.4825	1.7923	19.5888	8.2032	7.5471	16.375	5.8503
14:31	0.002	0.0042*	0.0254***	0.0109***	0.0155***	0.0347***	0.0046
	0.8367	1.8865	6.0561	3.4692	5.2675	8.515	0.9856
14:32	0.0001	0.0055**	0.0166***	0.0043*	0.007***	0.0103***	0.0054
	0.0214	2.1928	5.3664	1.7024	2.8651	2.9333	1.4319
R-Sqr	0.4919	0.5308	0.7909	0.6222	0.6114	0.72	0.6393

The table shows the estimation results of Modification 1 for certain controldates for the DAX stocks. *,** and *** indicate significance on the 10%, 5% and 1% level. The lower 10 variables correspond to the dummy variables for the respective one minute interval following the stated daytime.

Table 7: Control Results DAX Modification 2

Date (2013)	March 28th	April 3rd	April 5th	April 11th	April 25th	May 3rd	May 9th
Constant	0.0385***	0.0326***	0.0467***	0.0354***	0.0538***	0.0543***	0.0552***
	17.0134	21.4021	20.1291	18.6611	20.4696	16.0919	15.704
Traden.	-0.0001	-0.0001**	-0.0002***	-0.0001**	-0.0001***	-0.0001***	-0.0002**
	-0.9975	-2.3189	-3.8298	-2.3046	-3.7507	-4.1158	-2.4354
Volume	0.0004	0	-0.0006	0.0002	0.0005*	0.0002	0.0006
	0.8103	0.0258	-1.2048	0.5235	1.8911	1.1524	0.9344
QPPC	28.5367***	41.6308***	7.6547	52.8748***	26.939***	14.8769**	38.3326***
	4.0362	3.5068	1.3529	4.2347	4.4273	2.5042	3.9667
13:43	0.0032	-0.001	-0.005**	0.0046	0.0007	-0.0026	0.0016
	0.9325	-0.5014	-2.1465	1.5744	0.1837	-0.7146	0.4656
13:44	0.0067**	0.0027	-0.0034	0.0018	0.0015	0.0029	-0.0037
	2.3941	1.1232	-1.199	0.7777	0.5834	0.8363	-1.1614
13:45	0.0027	0.0006	-0.0066**	0.0019	-0.0029	-0.0017	-0.0019
	0.925	0.269	-2.1334	0.5974	-1.2129	-0.5408	-0.5672
13:46	0.0032	0.0018	-0.0032	0.0013	0.0004	-0.0005	0.0018
	0.9448	0.902	-1.0941	0.4901	0.1433	-0.1366	0.4008
13:47	0.0031	0.0073***	-0.0021	0.0019	-0.0018	-0.001	-0.0015
	1.075	2.6019	-0.7857	0.6323	-0.7511	-0.2692	-0.4531
14:28	0.0037	0.0052**	0.0026	0.0003	0.0013	0.0038	0.0045
	1.3075	2.1404	1.032	0.1218	0.549	0.9864	1.0879
14:29	0.007**	0.0037	0.0264***	0.0111***	0.0179***	0.0215***	0.0211***
	2.0289	1.2807	8.6447	3.8135	5.0786	4.9588	4.0485
14:30	0.0083***	0.0049*	0.1576***	0.0286***	0.0312***	0.0823***	0.0301***
	3.6768	1.7335	18.6408	8.212	7.5513	14.9439	6.1543
14:31	0.0021	0.0044*	0.026***	0.0114***	0.0156***	0.0343***	0.0049
	0.8594	1.9551	6.1934	3.6062	5.4317	8.0581	1.0352
14:32	0.0001	0.0055**	0.0178***	0.0044*	0.0072***	0.0108***	0.0067**
	0.0239	2.1745	5.4277	1.7235	2.9345	3.0344	1.8226
R-Sqr	0.4911	0.5296	0.7898	0.6205	0.6098	0.721	0.6331

The table shows the estimation results of Modification 2 for certain controldates for the DAX stocks. *,** and *** indicate significance on the 10%, 5% and 1% level. The lower 10 variables correspond to the dummy variables for the respective one minute interval following the stated daytime.

Table 8: Control Results CAC General Model

Date (2013)	March 28th	April 3rd	April 5th	April 11th	April 25th	May 3rd	May 9th
Constant	0.0424***	0.0433***	0.0456***	0.0472***	0.0487***	0.0387***	0.0514***
	12.7336	16.8302	13.9018	13.026	13.7517	13.4006	14.8809
Traden.	0	0	-0.0001**	0.0001**	-0.0001**	0	0.0001*
	0.6293	-1.2793	-2.4885	2.4564	-1.9876	-0.1271	1.8726
Volume	-0.0011**	-0.0006	-0.0003	-0.0024**	-0.0002	-0.0003	0.0015*
	-2.0541	-0.982	-0.7161	-2.2205	-0.2314	-0.3322	1.6307
13:43	0.0101***	0.007**	0.0018	-0.0043	-0.0055	0.0051	-0.0076**
	2.6693	2.3293	0.5129	-0.9129	-1.4425	1.4316	-1.9934
13:44	0.0058	0.0008	0.0055	0.0012	-0.0037	0.0071**	-0.0089**
	1.4744	0.3709	1.4027	0.3156	-1.0457	2.1059	-2.3165
13:45	0	0.0035	-0.0039	0.0032	-0.0035	0.0069**	-0.0079**
	-0.011	1.2662	-1.0544	0.9266	-0.9936	2.0693	-1.9921
13:46	-0.0011	0.0051*	-0.0032	0.0051	-0.0077**	0.0077*	-0.0046
	-0.3254	1.9281	-0.7793	1.1562	-2.3334	1.9386	-1.0307
13:47	0.0032	0.0083***	0.0015	-0.0014	-0.0089***	0.006*	-0.0056
	0.839	2.8714	0.3747	-0.3734	-2.7771	1.7268	-1.4924
14:28	0.0042	0.0099***	0.0018	0.0056	-0.006*	0.0077*	-0.0033
	1.131	3.6518	0.4979	1.4165	-1.8909	1.7764	-0.8534
14:29	0.0028	0.0097***	0.0228***	0.0258***	0.0055	0.0333***	0.011**
	0.7266	2.921	5.1296	5.7876	1.3294	7.3841	2.5678
14:30	0.0056	0.0105***	0.1096***	0.036***	0.0266***	0.0783***	0.0268***
	1.5853	3.5364	16.7786	7.1445	5.7546	12.7345	4.6095
14:31	0.0007	0.0035	0.0238***	0.0077**	0.0022	0.0307***	-0.0021
	0.195	1.2497	5.8012	2.1542	0.5789	8.8036	-0.4604
14:32	-0.0022	0.0087***	0.0184***	0.0089**	0.0047	0.0158***	-0.0052
	-0.6319	2.7801	5.4786	2.288	1.4386	4.3514	-1.3037
R-Sqr	0.4086	0.442	0.6339	0.4915	0.4028	0.5176	0.5195

The table shows the estimation results of the general model for certain controldates for the CAC stocks. *,** and *** indicate significance on the 10%, 5% and 1% level. The lower 10 variables correspond to the dummy variables for the respective one minute interval following the stated daytime.

Table 9: Control Results CAC Modification 1

Date (2013)	March 28th	April 3rd	April 5th	April 11th	April 25th	May 3rd	May 9th
Constant	0.0383***	0.0388***	0.0498***	0.0609***	0.043***	0.0425***	0.0406***
	15.4093	13.7691	16.5421	16.1263	15.02	17.8156	14.015
Traden.	0	0	-0.0001***	0.0001*	-0.0001**	0	0.0001
	0.0691	-1.1884	-2.6358	1.751	-2.5686	-0.2008	1.5383
Volume	-0.0013**	-0.0007	-0.0004	-0.0022**	0	-0.0005	0.0016*
	-2.353	-1.2298	-0.9938	-1.9871	0.0203	-0.5772	1.6947
APPC	0.0352***	0.0301***	0.026***	0.0504***	0.0393***	0.0308***	0.0432***
	4.1696	3.5777	3.1999	5.0272	4.4738	3.2554	3.7311
13:43	0.0132***	0.0037	-0.0036	-0.0039	-0.0022	-0.0003	-0.0021
	4.3888	1.0889	-1.1191	-0.7858	-0.6668	-0.0988	-0.638
13:44	0.0092***	-0.0017	0.0003	0.0011	-0.0004	0.0019	-0.0022
	2.8901	-0.6318	0.0885	0.2744	-0.1297	0.6639	-0.7004
13:45	0.0032	0.0014	-0.009***	0.0024	-0.0003	0.0015	-0.0024
	1.0676	0.429	-2.6133	0.6414	-0.0896	0.5328	-0.6915
13:46	0.0019	0.0031	-0.0083**	0.0046	-0.0046*	0.0023	0.0007
	0.6914	1.0294	Pa.1809	0.9713	-1.7021	0.6598	0.1609
13:47	0.0067**	0.0056**	-0.0037	-0.0014	-0.0056**	0.0007	-0.0001
	2.2058	1.6944	-1.0051	-0.3544	-2.156	0.2373	-0.0354
14:28	0.0072**	0.0067**	-0.0036	0.0055	-0.0031	0.0019	0.0025
	2.5264	2.1343	-1.0718	1.2738	-1.218	0.5075	0.7444
14:29	0.0057*	0.0076**	0.017***	0.0248***	0.0063**	0.0272***	0.0169***
	1.8014	2.0385	4.0763	5.3488	2.0959	6.5205	4.4647
14:30	0.0092***	0.0081**	0.0992***	0.0355***	0.0293***	0.0679***	0.0313***
	3.3515	2.4086	15.1526	6.7639	7.0144	10.6791	5.6039
14:31	0.004	0.0005	0.0173***	0.0063	0.0045	0.0217***	0.0027
	1.6295	0.1573	4.4048	1.6002	1.333	6.304	0.6686
14:32	0.0008	0.0066*	0.0108***	0.0086**	0.0081***	0.01***	0.0003
	0.3008	1.9138	3.4362	2.0548	3.0539	3.2079	0.0785
R-Sqr	0.4146	0.4442	0.6396	0.5072	0.4222	0.521	0.5266

The table shows the estimation results of Modification 1 for certain controldates for the CAC stocks. *,** and *** indicate significance on the 10%, 5% and 1% level. The lower 10 variables correspond to the dummy variables for the respective one minute interval following the stated daytime.

Table 10: Control Results CAC Modification 2

Date (2013)	March 28th	April 3rd	April 5th	April 11th	April 25th	May 3rd	May 9th
Constant	0.0393***	0.0394***	0.0507***	0.0621***	0.044***	0.0436***	0.0412***
	16.0653	13.943	17.1909	16.3283	15.4114	18.3915	14.0879
Traden.	0	0	-0.0001***	0.0001	-0.0001***	0	0.0001*
	0.2306	-1.2265	-3.0513	1.4277	-2.6761	-0.1291	1.6584
Volume	-0.0012**	-0.0007	-0.0005	-0.002*	0.0001	-0.0004	0.0016*
	-2.2746	-1.2368	-1.1991	-1.835	0.1969	-0.4682	1.6517
QPPC	12.1569**	16.7874***	12.4533***	27.415***	21.3923***	5.5552	18.695**
	2.4065	3.157	4.6436	4.2648	4.8933	1.1292	2.1006
13:43	0.0132***	0.004	-0.0038	-0.0038	-0.0022	0	-0.0015
	4.3985	1.1541	-1.1717	-0.7637	-0.6662	0.0121	-0.4415
13:44	0.0091***	-0.0016	0	0.0013	-0.0004	0.002	-0.002
	2.8494	-0.5735	-0.0084	0.3194	-0.136	0.6951	-0.6051
13:45	0.0031	0.0014	-0.0094***	0.0025	-0.0002	0.0018	-0.002
	1.0274	0.4474	-2.7365	0.6509	-0.075	0.6278	-0.579
13:46	0.0019	0.0033	-0.0086**	0.0046	-0.0046*	0.0026	0.0013
	0.7251	1.104	-2.2575	0.9634	-1.7158	0.7214	0.3182
13:47	0.0065**	0.0057*	-0.0042	-0.0014	-0.0057**	0.001	0.0002
	2.1494	1.7065	-1.119	-0.3338	-2.1815	0.3151	0.0654
14:28	0.0073**	0.0071**	-0.0038	0.0055	-0.0031	0.0023	0.0029
	2.5565	2.243	-1.1074	1.2754	-1.2239	0.6059	0.8354
14:29	0.0059*	0.0077**	0.017***	0.0252***	0.0064**	0.028***	0.0175***
	1.8806	2.0796	4.0641	5.3842	2.1129	6.6866	4.5033
14:30	0.0091***	0.0082**	0.096***	0.036***	0.0296***	0.0704***	0.032***
	3.3153	2.4345	14.426	6.9089	7.1048	10.5444	5.6958
14:31	0.004	0.0007	0.0174***	0.0065*	0.0046	0.0237***	0.0035
	1.6414	0.2301	4.4409	1.6587	1.3704	6.5409	0.8312
14:32	0.0009	0.0069**	0.0109***	0.0089**	0.0081***	0.0106***	0.0007
	0.3456	1.9928	3.5004	2.1201	3.0494	3.3411	0.203
R-Sqr	0.4119	0.4434	0.6411	0.5062	0.4219	0.5185	0.524

The table shows the estimation results of Modification 2 for certain controldates for the CAC stocks. *,** and *** indicate significance on the 10%, 5% and 1% level. The lower 10 variables correspond to the dummy variables for the respective one minute interval following the stated daytime.

Table 11: Control Results FTSE General Model

Date (2013)	March 28th	April 3rd	April 5th	April 11th	April 25th	May 3rd	May 9th
Constant	0.0651***	0.0229***	0.0267***	0.0536***	0.0647***	0.081***	0.1094***
	17.5775	8.9337	8.3979	14.2088	12.937	19.3155	13.3623
Traden.	0.0001***	0.0001***	0	0.0002***	0.0002***	0.0001***	0.0001**
	3.9698	2.7749	0.5303	4.821	5.9034	3.6119	2.2926
Volume	0	-0.0002	0.0002	-0.0004***	-0.0007***	0.0001	-0.0002**
	-0.3218	-1.3221	1.5462	-2.6719	-5.31	1.1887	-1.9756
13:43	-0.0011	0.005	0.0006	-0.0003	-0.0053	-0.0011	-0.0093*
	-0.3258	1.2216	0.1538	-0.0873	-0.8837	-0.2717	-1.8492
13:44	0.0039	0.0037	-0.0033	0.0028	-0.0056	-0.0001	-0.002
	1.2633	1.0075	-0.9077	0.8042	-0.9856	-0.0325	-0.3639
13:45	0.0077**	-0.0009	-0.0023	-0.0002	-0.01**	-0.0049	-0.0051
	2.1916	-0.3052	-0.6044	-0.0505	-1.9415	-1.4171	-0.8902
13:46	0.0035	0.0004	-0.0062	0.002	-0.0042	-0.0019	-0.0033
	0.9959	0.1116	-1.6305	0.5879	-0.7895	-0.4678	-0.5548
13:47	0.0096***	0.0019	0.0019	-0.0013	-0.011**	-0.0024	-0.0087*
	2.6222	0.582	0.4861	-0.404	-2.1887	-0.5945	-1.6789
14:28	0.0013	0.0039	0.003	-0.0022	-0.0055	-0.0058	-0.0077
	0.4223	1.1003	0.694	-0.7337	-1.1077	-1.5318	-1.4646
14:29	0.0071**	0.0016	0.0355***	0.0241***	0.0159**	0.0311***	0.0092
	2.3796	0.4717	6.8278	6.185	2.5125	6.0533	1.5661
14:30	0.0059**	0.0038	0.0849***	0.0377***	0.0327***	0.0596***	0.0349***
	2.067	1.0685	13.777	7.397	5.1581	10.8949	4.8967
14:31	0.0067**	0.0019	0.0311***	0.0079**	0.0021	0.0235***	-0.0006
	2.2781	0.5684	6.9386	2.4339	0.3934	5.7057	-0.1046
14:32	0.0043	0.0077**	0.021***	0.0117***	-0.0019	0.0133***	-0.0054
	1.5241	2.1991	4.5153	3.1714	-0.3628	3.7755	-0.9963
R-Sqr	0.7057	0.6912	0.726	0.7362	0.6674	0.7543	0.7956

The table shows the estimation results of the general model for certain controldates for the FTSE stocks. *,** and *** indicate significance on the 10%, 5% and 1% level. The lower 10 variables correspond to the dummy variables for the respective one minute interval following the stated daytime.

Table 12: Control Results FTSE Modification 1

Date (2013)	March 28th	April 3rd	April 5th	April 11th	April 25th	May 3rd	May 9th
Constant	0.0916***	0.0547***	0.1064***	0.0512***	0.0521***	0.0651***	0.0444***
	40.1934	17.7918	20.039	12.1511	10.9585	14.6809	12.7179
Traden.	0.0001***	0.0001***	0	0.0001***	0.0001**	0	0
	2.9519	2.6472	0.1779	3.1243	2.3868	0.9966	1.3706
Volume	0	-0.0002	0	-0.0003*	-0.0005***	0	-0.0001**
	-0.044	-1.2609	0.3171	-1.9229	-4.4608	-0.2094	-2.2136
APPC	0.0923***	0.0788***	0.1029***	0.082***	0.1113***	0.1019***	0.1063***
	10.6462	8.6811	10.6011	8.4126	10.2929	9.1529	10.2356
13:43	-0.003	0.0058*	0.0008	-0.0037	0.0022	-0.0057	-0.0006
	-0.9653	1.6929	0.218	-0.8733	0.3849	-1.4981	-0.2069
13:44	0.0027	0.0039	-0.0033	-0.0017	0.002	-0.0044	0.0054
	0.9161	1.2542	-0.995	-0.3913	0.3838	-1.1097	1.5824
13:45	0.0055*	0.0001	-0.0038	-0.0023	-0.0018	-0.0075**	0.0023
	1.6951	0.0558	-1.0956	-0.5672	-0.3684	-2.1878	0.6287
13:46	0.0025	0.0008	-0.0067**	0.0009	0.0034	-0.0068*	0.0053
	0.7377	0.2501	-2.0712	0.2182	0.6599	-1.7342	1.3224
13:47	0.0077**	0.0023	0.0012	-0.0034	-0.0041	-0.0066*	0.0017
	2.2231	0.8214	0.3442	-0.8455	-0.8666	-1.7335	0.5581
14:28	0.0006	0.0033	0.0013	-0.004	0.0005	-0.0076**	0.0005
	0.1949	1.0384	0.3462	-1.0231	0.1205	-2.0857	0.1632
14:29	0.0052*	0.0031	0.0318***	0.0257***	0.0191***	0.0248***	0.0186***
	1.7612	0.9984	7.1412	4.935	3.3263	4.997	4.5401
14:30	0.0041	0.0048	0.072***	0.0338***	0.0387***	0.0572***	0.0393***
	1.4565	1.5897	13.4439	5.9652	6.4039	8.8068	7.5115
14:31	0.0052*	0.004	0.0254***	0.0021	0.0081	0.0119***	0.0055
	1.6784	1.3681	6.5356	0.5309	1.5721	2.7929	1.3258
14:32	0.002	0.0086***	0.0132***	0.008*	0.0048	0.0061*	0.0037
	0.7087	2.8415	3.1901	1.7961	0.9495	1.6633	1.1735
R-Sqr	0.7078	0.6919	0.7433	0.7449	0.6912	0.7398	0.798

The table shows the estimation results of Modification 1 for certain controldates for the FTSE stocks. *,** and *** indicate significance on the 10%, 5% and 1% level. The lower 10 variables correspond to the dummy variables for the respective one minute interval following the stated daytime.

Table 13: Control Results FTSE Modification 2

Date (2013)	March 28th	April 3rd	April 5th	April 11th	April 25th	May 3rd	May 9th
Constant	0.0919***	0.056***	0.1089***	0.0534***	0.0554***	0.0686***	0.045***
	40.4154	18.2524	19.7253	12.8289	11.9533	15.6474	12.6422
Traden.	0.0001***	0.0001***	0	0.0001***	0.0001***	0.0001*	0.0001
	3.4212	2.9992	0.896	3.3856	2.6382	1.6598	1.4855
Volume	0	-0.0002	0	-0.0003*	-0.0005***	0	-0.0001**
	-0.2842	-1.3479	0.3552	-1.8613	-4.5049	-0.3042	-2.0597
QPPC	40.0085***	47.8593***	24.5715***	33.6735***	27.8752***	35.0906***	36.8259***
	6.974	6.662	5.2197	4.4918	4.4255	5.9791	6.2213
13:43	-0.0025	0.0063*	0.0014	-0.0028	0.0035	-0.0052	0.0018
	-0.8065	1.8424	0.3887	-0.6818	0.6191	-1.3376	0.6234
13:44	0.0034	0.0044	-0.002	-0.0015	0.0025	-0.0035	0.0073**
	1.1434	1.4329	-0.588	-0.3532	0.4848	-0.8709	2.0731
13:45	0.0055*	0.0007	-0.0023	-0.002	-0.0011	-0.0071**	0.0039
	1.6707	0.2565	-0.655	-0.4869	-0.2354	-2.0863	1.024
13:46	0.0029	0.0015	-0.0057*	0.0011	0.0044	-0.0059	0.0069*
	0.8685	0.4784	-1.7503	0.2748	0.8776	-1.4841	1.7001
13:47	0.0084**	0.0032	0.0021	-0.0031	-0.0026	-0.0061	0.0026
	2.3924	1.1259	0.617	-0.788	-0.5485	-1.5793	0.8522
14:28	0.0009	0.0038	0.0034	-0.0036	0.0025	-0.0072**	0.0017
	0.2943	1.1983	0.8736	-0.9297	0.5645	-1.9702	0.5248
14:29	0.0059**	0.0036	0.034***	0.026***	0.0214***	0.0264***	0.0203***
	1.9975	1.1881	7.5218	5.0069	3.7688	5.3395	4.8415
14:30	0.005*	0.0051*	0.0761***	0.035***	0.0413***	0.0587***	0.0412***
	1.7755	1.6978	13.8814	6.1947	6.889	9.0072	7.9516
14:31	0.0056*	0.0046	0.0285***	0.0033	0.0095*	0.0132***	0.0072*
	1.7964	1.5793	7.2946	0.8277	1.8768	2.9649	1.7188
14:32	0.0028	0.0091***	0.0173***	0.0092**	0.0066	0.0079**	0.0049
	1.0041	3.022	4.1278	2.0939	1.3382	2.1387	1.5283
R-Sqr	0.7045	0.6907	0.7372	0.7418	0.6847	0.7376	0.7953

The table shows the estimation results of Modification 2 for certain controldates for the FTSE stocks. *,** and *** indicate significance on the 10%, 5% and 1% level. The lower 10 variables correspond to the dummy variables for the respective one minute interval following the stated daytime.

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