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The Impact of US Macroeconomic News on the Prices of Single Stocks on the Vienna Stock Exchange

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Abstract

Recent studies have shown that announcements of information about the state of the US economy have had a significant impact on European stock markets. However, the importance of information about the US economy may vary in time. In order to analyze this issue, we examine the impact of announcements of unexpected US macroeconomic news on the prices of selected stocks listed on the Vienna Stocks Exchange. On the basis of the 5-minute returns of 13 stocks we examine how the strength and the significance of the reactions of investors to unexpected macroeconomic news from the US has changed over the last 15 years. Event study methodology allows us to describe precisely such reactions in the first minutes after news announcements.

Keywords: event study, macroeconomic announcements, intraday data

JEL Classification: G14, E44

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1 Introduction

In contemporary economics the performance of stock exchanges has an essential impact on the real economy, while data on the real economy impacts stock exchanges. The ultimate direction of interaction depends on the size of the economy that is the source of the data. Therefore, we can expect that the most influential macroeconomic data comes from the US. It is clear that due to globalization not only US stock exchanges, but also other stock exchanges can be impacted by US macroeconomic data.

The first studies investigated the impact of US macroeconomic data on the US and on large developed markets (e.g. Schwert, 1981; Pearce and Roley, 1985; Li and Hu, 1998; Nikkinen and Sahlström, 2004; Boyd et al., 2005; Andersen et al., 2007; Harju and Hussain, 2011). The emerging markets, especially in Central and Eastern Europe (CEE) and small developed markets were only of limited interest in financial journals (e.g. Hanousek et al., 2009; Gurgul and Wójtowicz, 2015).

Research on stock market reactions to news from the US economy has been conducted using several methods and for different time periods. Therefore, it is not easy to evaluate the results and compare them in turbulent and calm time periods.

The main goal of our study is to examine the impact of unexpected news about the US economy on returns of stocks listed on the Vienna Stock Exchange (VSE). In order to assess the reaction to the US data we use 5-minute returns based on tick-by-tick data of the largest companies listed on the VSE from January 2006 to the end of June 2020. Using intraday data allows us to establish the strength and significance of the impact of US macroeconomic news right after its release. The additional advantage of this data is the length of the period under consideration because it includes both the time of bull market and bear market time periods. In particular, it covers two large financial crises: the global financial crisis of 2007–2009 (which originated in the USA) and the European debt crisis of 2010–2014. This heterogeneity of data applied in this paper allows us to analyze how the reactions of investors on the VSE have changed over time and how the impact of unexpected macroeconomic news from the US economy has changed according to the state of the global economy.

The majority of papers concerning the impact of macroeconomic news on stock markets are based on index data. This paper extends previous studies by applying event study methodology to intraday data of single stocks. This allows us to analyze how specific company characteristics impact the way new information is incorporated into stock prices. This price formation process cannot be directly observed in the case of market index data because the index is an average of the prices of single stocks.

The remainder of the paper is organized as follows. In the next section we give a short overview of the literature on the effects of macroeconomic announcements on financial markets. In Section 3 we describe the US macroeconomic indicators and returns used in this study. We also give some brief information about the event study methodology used. The empirical results and discussion of results are presented in Section 4. The final section concludes the paper.

2 Literature review

Macroeconomic news announcements are the most important risk factors for financial markets. This is the case because the state of the economy reflected in these announcements is one of the main sources of risk. Moreover, this source of risk cannot be accounted for as a diversifiable risk.

The first studies concerning the effects of US macroeconomic data announcements focused on the US stock market (Geske and Roll, 1983; McQueen and Roley, 1993). Over the following years studies were carried out with respect to developed markets. The results confirmed the importance of macroeconomic news from the US economy. In the economic literature many examples of the impact of foreign macroeconomic news on domestic financial markets can be found. This is the case in the study by Hanousek et al. (2009) concerning the response of asset prices to macroeconomic announcements in three CEE countries: the Czech Republic, Hungary and Poland using intraday data. The authors found that the Czech stock market is impacted more by US macroeconomic announcements than by EU macroeconomic announcements.

Kroencke et al. (2016) emphasize that the relationship between financial markets and macroeconomic announcement risk can arise through two pathways:

(a) news on macroeconomic data which is sometimes published unexpectedly,

and the more probable and important second channel

(b) even if news of macroeconomic variables appears on the pre-scheduled date, the exact values of these factors can only be estimated.

Therefore, it is essential to measure expectations regarding the macroeconomic announcements. In this case, consensus estimates of professionals are highly appreciated. They are thought to be a reliable source for predicting these values. According to the semi-strong form of the efficient market hypothesis formulated by Fama (1970), the forecasted values are already included in the pricing of an asset after the consensus data are published. However, a component is still preserved in the form of the not unexpected difference between the predicted and the announced data. This value is known in the literature as the surprise component.

Ederington and Lee (1993) found a significant effect of regularly scheduled US macroeconomic announcements on the volatility of the US treasury and foreign exchange futures.

In their study Nikkinen and Sahlström (2004) tried to identify the effects of US and German and Finnish macroeconomic news on the German and Finnish stock markets, and the most important role of information from the US came to light. The authors detected that volatility in both markets reacts significantly only to US macroeconomic announcements, on the unemployment rate and PPI. This group of stock markets was also the subject of research by Nikkinen et al. (2006). They analyzed the impact of US macroeconomic news announcements on 35 stock markets all around the world. This

sample also contained some developed and emerging markets from Europe. The result was that unexpected US macroeconomic announcements have effects on volatility on developed stock markets in Europe and Asia. According to this study the reaction of volatility from emerging CEE markets (the Czech Republic, Hungary, Poland, Russia and Slovakia) to announcements of US macroeconomic indicators was not significant. However, this observation may not be correct due to the use of data from the early period of the development of stock markets in the CEE region. This remark is justified by the opposite results shown by Gurgul et al. (2012) obtained on the basis of data from January 2004 to December 2011. These results confirmed a significant reaction of the daily returns of the Polish index WIG20 to unexpected US news on inflation and industrial production in the US.

Bredin et al. (2007) used event study methodology to conduct a comprehensive study on the impact of changes in UK monetary policy on UK stock returns. He tried to find the possible reasons for such responses. They assessed the effects of unexpected changes in monetary policy on aggregate and sectoral stock returns. This kind of decomposition of unexpected changes in the policy rate was based on futures markets data. The authors used variance decomposition, and found the pathways of the response of stock returns to monetary policy surprises. Their results indicate that monetary policy shocks cause a persistent negative response in terms of future excess returns for a number of sectors.

More precise and reliable results on the effects of US macroeconomic news on European markets were obtained in different studies by applying intraday data. Based on five-minute returns Andersen et al. (2007) proved the impact of US macroeconomic news on US, German and British stock, bond and foreign exchange markets. Harju and Hussain's study (2011) is also based on high-frequency data. The authors checked the impact of scheduled US macroeconomic announcements on four developed stock markets from Europe, namely the British, French, German and Swiss ones. They established that announcements of CPI, PPI, retail sales, durable goods orders, unemployment rate and industrial production are sources of essential and prompt changes in volatility and 5-minute returns of CAC40, DAX30, FTSE100 and SMI. In line with these results were those published by Dimpfl (2011). He dealt with 1-minute DAX returns between July 2003 and December 2006. Dimpfl found that investors on the Frankfurt Stock Exchange react almost immediately after a news release. This reaction is visible not later than ten minutes after.

Gurgul and Wójtowicz (2015) proved the reaction of the Austrian stock exchange to US macroeconomic news. Taking into account 1-minute returns of ATX from 2 January 2007 to 31 December 2013 they proved the significant impact of the announcements of 10 US macroeconomic indicators on returns and volatility. The most significant reaction was after the release of news from the US labor market (nonfarm payrolls announcements). Gurgul and Wójtowicz (2015) also checked the dynamics of the strength of the reaction of ATX to US macroeconomic announcements in this period. From this study it follows that the strongest reaction of ATX to US

macroeconomic news was in 2007–2009. The reaction after this time was essentially weaker.

The effects of macroeconomic news on foreign exchange markets in CEE countries were examined by Égert and Kočenda (2014). They found that the exchange rates of the currencies of the Czech Republic, Hungary and Poland react to American macroeconomic news announcements. However, this reaction is not unique in the time periods (2004–2007) and (2008–2009).

In contrast to other contributions on the role of US announcements for the performance of small stock markets in Europe, especially Vienna Stock Exchange, our study is conducted on the basis of tick-by-tick data for individual constituents of the ATX index. This comprehensive analysis based on data for single companies enables more accurate insight into the role of macroeconomic news with respect to stock market performance determined by Austrian blue chips. Our results shed new light on the mechanisms by which new information in US macroeconomic news influenced the stock prices of companies listed on the Vienna Stock Exchange.

3 Data and methodology

3.1 Announcements

In this paper we investigate the impact of the announcements of 19 macroeconomic indicators that describe various aspects of the US economy. They are Consumer Confidence Index (CCI), Consumer Price Index (CPI), CPI less food and energy (cCPI), Durable Goods Orders (DGO), Existing Home Sales (EHS), Housing Starts (HS), Industrial Production (IP), ISM Manufacturing Index (ISM), Initial Jobless Claims (IJC), Leading Indicators (LI), New Home Sales (NHS), Nonfarm Payrolls (NFP), Personal Income (PI), Philadelphia Fed Business Outlook Survey (PFBOS), Producer Price Index (PPI), PPI less food and energy (cPPI), Real GDP (GDP), Retail Sales (RS), and Retail Sales less autos (cRS).

We have chosen these indicators because they contain the most current information that is important for investors. Almost all these indicators are released monthly and they describe the economic situation in the US in the previous (or even in the current) month. The only exception is IJC, which is announced weekly and contains information from the previous week. This also ensures that the number of announcements required to conduct the study is sufficient. The other advantage of the indicators is that they have been widely studied in the literature. Hence, we can compare the results of the analysis with previous results.

All the indicators under consideration are released during trading hours on the Vienna Stock Exchange. Most of them (CPI, DGO, HS, IJC, NFP, PPI, GDP, and RS) are published at 8:30 EST (Eastern Standard Time), CCI, EHS, ISM, and NHS are released at 10:00 EST and only values of IP are announced at 9:15 EST. The release times of these indicators correspond to 14:30 CET (Central European Time),

15:15 CET, 16:00 CET, respectively. Due to the differences in the transition from summer to winter time (and vice versa) in the US and Europe a one-hour shift in the release time must be taken into account at the end of March and at the turn of October and November.

These announcements are released on different days of the month and different days of the week. The sequence in which US macroeconomic indicator announcements are released may play an important role in the perception of them by investors. The earlier the indicator is released, the more important it is for investors because it is more probable that it contains new, unexpected information. The value of the next indicator released later in the month can be forecasted on the basis of the value of earlier indicators. The earliest published indicator is ISM, which is announced during the first few days of the month. Then, it is followed by NFP, which is a part of the Employment Report published by the Bureau of Labor Statistics, usually on the first Friday. The majority of the other indicators (CPI, EHS, HS, IP, PPI, and RS) are released mainly in the middle of the month, around the 15^{th}. The rest of them (CCI, DGO, NHS, and GDP) are released on the last few days of the month. However, it should be noted here that the values of CCI describe consumers' perceptions of the economic conditions in the current month.

In this paper we study the impact of unexpected news contained in US macroeconomic announcements. Thus, for each macroeconomic news release the actual value of the announced indicator is compared to its consensus forecast. All comparisons are made on the basis of the consensus published by Econoday a few days before announcements. Application of consensus is a common way of defining of market expectations (see for example Balduzzi et al., 2001; Kurov et al. 2019). This comparison allows us to divide all releases into three clusters: 'above consensus', 'below consensus' and 'in line with consensus'. Because the news in the last cluster is in line with previous investor expectations, our analysis focuses on only the first two clusters, which contain unexpected news.

In order to correctly interpret the results of the analysis we divide the announcements according to their meaning rather than make a simple comparison to the consensus. For most of the indicators an announcement above consensus is good news because it is expected to have a positive impact on a stock market. The only exception is the publications of CPI, PPI and IJC whose values greater than forecasts are expected to have a negative impact on stock prices (bad news). Analogously, a value of CPI, PPI and IJC lower than forecast is defined as good news for a stock market, while in the case of the other indicators it is bad news for investors. On the basis of this consideration we divide all the announcements into two categories of unexpected news: good news and bad news. We will analyze these two sets of data empirically. In addition to analyzing the impact of the announcements of an individual indicator, we also examine the impact of all good and all bad news. In the set of all good (bad) news we take into account only monthly announcements, i.e. excluding IJC announcements released weekly. Additionally, when two or more indicators are announced on the same

day, we consider only the first of them. Subsequent announcements on the same day are excluded from the sample because expectations about their value could be heavily influenced by earlier news and thus they might be different from consensus. When two or more announcements are made at the same time we only take them into account if they do not contain contradictory information, i.e. when each of them is good news, or each of them is bad news.

3.2 Returns

To correctly describe the impact of US macroeconomic announcements on investors operating on the Vienna Stock Exchange we study 5-minute percentage log-returns $R_{j,t}$ of the largest and the most liquid stocks listed on the VSE in the period from 2 January 2006 to 31 June 2020:

$$R_{j,t} = 100 \left(\ln P_{j,t} - \ln P_{j,t-1} \right), \tag{1}$$

where $P_{j,t}$ is a stock price at the end of t-th 5-minute period on day j.
Application of 5-minute intraday returns is common as a compromise between accuracy and the negative effects of market microstructure (e.g. Jones et al., 2005; Andersen et al. 2007; Harju and Hussain, 2011). In order to reduce the impact of market microstructure, only stocks of companies with a very large number of transactions can be taken into account. Table 1 presents the names and symbols of the most liquid stocks from the ATX considered in this paper whereas in Table 2 we present the average number of transactions per minute in individual years of the period under consideration. Values in Table 2 describe the intensity of trading in these stocks. It is worth noting here that according to speed of adjustment hypothesis, the speed at which new information is reflected in stock prices depends on stock liquidity. More actively traded stocks react faster to new information than stock which is not popular with investors.
From Table 2 we observe that the most heavily traded stocks in the whole period under consideration are EBS, OMV, VOE, and RBI. All of them usually have on average more than two transactions per minute. On the other hand EVN, MMK, SBO, POST, and TKA are characterized by the lowest number of transactions. On average MMK and EVN have about one transaction per 5-minute period (the average number of transactions per minute is about 0.2).
The period under consideration covers about 15 years characterized by changes in the economic situation in the United States and in the whole world. These changes include various crises that took place in that time. It is well known that volatility on stock markets increases during such turbulent periods. This phenomenon was also observed on the VSE. This is also visible in Figure 1 where we present values of standard deviation S_j computed for each day j on the basis of 5-min log-returns of VOE from days $j-20, \ldots, j+20$, i.e. in the window containing data from about one month before to about one month after that day. Due to these changes in volatility,

Table 1: Names of stocks

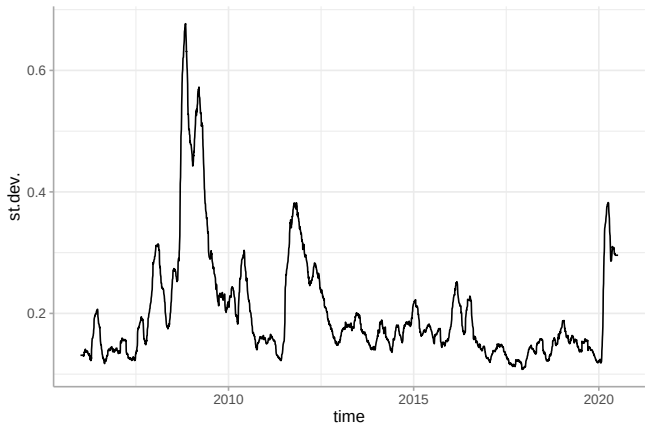
Symbol	Name	Subsector
ANDR	ANDRITZ AG	Industrial Engineering & Machinery
EBS	ERSTE GROUP BANK AG	Banking
EVN	EVN AG	Multi-Utilities
MMK	MAYR-MELNHOF KARTON AG	Packaging
OMV	OMV AG	Oil & Gas
POST	OESTERR. POST AG	Transportation
RBI	RAIFFEISEN BANK INTERNATIONAL AG	Banking
SBO	SCHOELLER-BLECKMANN OILFIELD EQUIPMENT AG	Oil & Gas
TKA	TELEKOM AUSTRIA AG	Telecommunications
VER	VERBUND AG KAT. A	Electric Utilities
VIG	VIENNA INSURANCE GROUP AG	Insurance
VOE	VOESTALPINE AG	Mining & Metals
WIE	WIENERBERGER AG	Construction Materials

Table 2: Average number of transactions per minute

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
ANDR	0.5	1.2	1.3	1.1	1.2	1.9	1.7	1.8	1.8	2.0	2.0	1.9	1.2	1.2
EBS	1.4	2.2	3.9	3.2	3.4	3.7	2.9	3.1	3.5	4.0	4.8	3.9	3.3	2.6
EVN	0.2	0.2	0.4	0.2	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.2	0.3	0.3
MMK	0.2	0.3	0.3	0.2	0.2	0.2	0.1	0.2	0.2	0.3	0.2	0.2	0.2	0.2
OMV	2.4	2.4	2.8	2.6	2.2	2.6	1.7	2.1	2.1	3.3	3.2	3.4	2.6	2.0
POST	0.6	0.5	0.5	0.8	0.5	0.5	0.5	0.5	0.6	1.1	0.9	0.9	0.5	0.4
RBI	1.2	1.9	3.1	2.0	2.1	1.9	1.4	1.4	3.0	2.9	2.6	2.9	2.5	1.7
SBO	0.2	0.3	0.4	0.4	0.3	0.5	0.4	0.4	0.5	0.9	0.9	1.1	0.7	0.5
TKA	1.1	1.6	2.0	1.7	1.3	1.6	1.2	1.1	1.1	0.6	0.6	0.7	0.3	0.2
VER	0.7	1.2	1.6	1.3	1.2	1.5	0.8	1.1	0.8	0.9	0.8	0.8	1.2	1.2
VIG	0.4	0.6	1.0	1.0	0.8	0.9	0.7	0.8	0.8	1.6	1.3	0.9	0.5	0.3
VOE	1.2	2.3	3.1	2.5	2.2	2.7	1.9	1.8	1.8	3.1	3.2	2.8	2.6	2.3
WIE	0.7	1.3	1.7	1.6	1.2	1.2	0.8	0.8	0.8	1.2	1.7	1.7	0.9	0.7

in order to compare the strength of the reaction of stock returns to publications of US macroeconomic indicators in various subperiods of the main period 2006–2020 we will also consider standardized 5-min returns $SR_{j,t}$ defined as 5-min log-returns $R_{j,t}$ divided by the corresponding standard deviation S_j defined as above for day j. In that case, standardized returns are expressed in terms of standard deviation of returns.

Figure 1: Standard deviations S_i of 5-min percentage log-returns of EBS in the period 2006–2020



Notes: For each day i this figure presents standard deviation of 5-min log-returns computed in the window $i-20,\ldots,i+20$. In these computations we take into account only intraday returns from continuous trading excluding the last and first 15 minutes of a trading session.

3.3 Event study

To investigate the impact of US macroeconomic news on the intraday returns of stocks form the VSE we use event study methodology. In brief, this is the analysis of the significance of the abnormal behavior of returns (abnormal returns) around the event (in the so-called event window). In this paper the events are defined as the announcements of unexpected macroeconomic news described in Section 3.1 and the event window contains three 5-minute returns before the announcement and twelve returns after it.

Abnormal returns are defined as the difference between actual returns and their expected values computed on the basis of data prior to the event window (from the pre-event window). For the i-th event and time t abnormal returns AR_{it} is defined as:

$$AR_{it} = R_{it} - E\left(R_{it}|\Omega\right), \tag{2}$$

where R_{it} is a 5-minute return and $E\left(R_{it}|\Omega\right)$ is the expectation of R_{it} conditional on information set Ω from the pre-event window. In this paper we consider a pre-event window containing 36 values of 5-minute returns just before the event window. This choice of the length of event and pre-event window ensures that the pre-event window starts no earlier than 10:25CET (when the macroeconomic indicator is announced at 13:30CET) and it does not contain intraday returns from the initial part of a trading

session with increased volatility. To set up the notation let us denote the moment of a news release with $t = 0$. Then the event window includes 5-minute returns for $t = -3, \ldots, 12$, while the pre-event window includes returns for $t = -39, \ldots, -4$. It should be noted here that the impact of the i-th news announcement can be observed only for $t \geq 1$.

There are various methods of computing expected values of R_{it}. In this paper, however, we apply a constant mean model where $E(R_{it}|\Omega)$ is equal to the average of returns in the pre-event window. It is a simple, but very useful and robust model (see for example Gurgul, 2012). As macroeconomic news impacts market indexes we cannot apply any CAPM-type models.

To test the significance of mean abnormal returns in the event window, we apply the nonparametric generalized rank test of Kolari and Pynnönen (2011) with a correction for event-implied volatility. The great advantage of this nonparametric test is that it does not require any assumption about the normality of abnormal returns. The test statistic is constructed as follows.

In the first step of the test procedure we group events into a cluster. The events are specific types of announcements, for example the announcements of a given macroeconomic indicator that are good (or bad) news for investors. For each i-th event in the cluster, for $t = -39, \ldots, 12$ we compute abnormal returns AR_{it} from (2) with $E(R_{it}|\Omega)$ computed earlier as the average of returns in the pre-event window ($t = -39, \ldots, -4$). Then, for each event, all abnormal returns in the event and pre-event windows are standardized:

$$SAR_{it} = \frac{AR_{it}}{S_{AR_i}}, \tag{3}$$

where S_{AR_i} is the standard deviation of abnormal returns in the pre-event window. This procedure ensures comparability of abnormal returns computed on the basis of data from days with high or low volatility.

To take into account increased volatility observed just after the event (Corrado, 2011; Corrado and Truong, 2008; Kolari, Pynnönen, 2011) we re-standardize the SAR_{it}s for $t > 0$ and divide them by their cross-sectional standard deviation:

$$SAR'_{it} = \begin{cases} SAR_{it} & t = -39, \ldots, 0 \\ SAR_{it}/S_{SAR_t} & t = 1, \ldots, 12, \end{cases} \tag{4}$$

where

$$S_{SAR_t} = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}\left(SAR_{it} - \overline{SAR_{it}}\right)^2} \tag{5}$$

is the cross-sectional standard deviation of standardized abnormal returns, and N is the number of events in the cluster. Under the null hypothesis of no news effect, SAR'_{it}s are zero mean and unit variance random variables.

We can use SAR'_{it} defined above to test the significance of the impact of the event for each t_0 in the event window separately. To perform such a test we define the demeaned standardized abnormal ranks of SAR'_{it} for each $t_0 = -3, \ldots, 12$ as:

$$U_{it} = \frac{\text{rank}\left(SAR'_{it}\right)}{T+1} - 1/2 \tag{6}$$

for $i = 1, \ldots, N$, where $t \in \Theta = \{-39, \ldots, -4, t_0\}$, $T-1$ is the length of the pre-event window and $\text{rank}\left(SAR'_{it}\right)$ denotes the rank of SAR'_{it} within the vector consisting of standardized abnormal returns from the pre-event window and SAR'_{it_0}. With this notation U_{it_0} denotes the demeaned standardized abnormal rank of SAR'_{it_0} and hence the null hypothesis of no news can be written in the form:

$$E\left(U_{it_0}\right) = 0. \tag{7}$$

To test it we use the generalized rank t_{grank} test statistic of Kolari-Pynnönen (2011)

$$t_{\text{grank}} = Z\sqrt{\frac{T-2}{T-1-Z^2}}, \tag{8}$$

where $Z = \overline{U}_{t_0}/S_{\overline{U}}$, $S_{\overline{U}} = \sqrt{\frac{1}{T}\sum_{t\in\Theta}\overline{U}_t^2}$ and $\overline{U}_t = \frac{1}{N}\sum_{i=1}^{N} U_{it}$.

Under the null hypothesis of no news effect, the distribution of the t_{grank} statistic converges to Student t distribution with $T-2$ degrees of freedom when the number of events N in the cluster increases.

It is worth emphasizing here that due to standardization (3) the application of the above procedure to the standardized returns defined in Section 3.2 instead of returns gives the same value of test statistic t_{grank}.

Analogously, to verify the cumulative impact of news announcements we test the significance of cumulative abnormal returns. For a given period τ the cumulative abnormal return is defined as

$$CAR_{i\tau} = \sum_{t=1}^{\tau} AR_{it}. \tag{9}$$

$CAR_{i\tau}$ describes the cumulative abnormal behavior of returns in the first τ periods just after the i-th event. The corresponding standardized cumulative abnormal return $CAR_{i\tau}$ is given by

$$SCAR_{i\tau} = \frac{CAR_{i\tau}}{S_{CAR_{i\tau}}}, \tag{10}$$

where $S_{CAR_{i\tau}} = \sqrt{\tau} S_{AR_i}$.

As above, $SCAR_{i\tau}$ are re-standardized:

$$SCAR'_{i\tau} = \frac{SCAR_{i\tau}}{S_{SCAR_{i\tau}}}, \tag{11}$$

where $S_{SCAR_{i\tau}}$is the cross-sectional standard deviation of $SCAR_{i\tau}$s. Finally, to compare abnormal returns in the pre-event window and cumulative abnormal return over the τ-period horizon we define generalized abnormal returns as

$$GSAR_{it} = \begin{cases} SAR_{it} & t = -39, \ldots, 0 \\ SCAR'_{i\tau} & t > 0. \end{cases} \tag{12}$$

To test the null hypothesis of no cumulative effect of US macroeconomic news announcements we apply t_{grank} statistic (8) with U_{it} defined on the basis of GSAR_{it}s instead of SAR'_{it}s.

Event study analysis and the Kolari-Pynnönen test procedure described above can also be performed on the basis of 5-minute standardized returns SR_{it} instead of returns R_{it}. In this case, the impact of the event is measured by abnormal standardized returns ASR_{it} defined analogously to (2) with $E(R_{it}|\Omega)$ replaced by $E(SR_{it}|\Omega)$. However, due to the application of the constant mean model and due to standardization (3) abnormal standardized returns ASR_{it} are equal to AR_{it} divided by the corresponding standard deviation S_i of 5-minute returns in 41-day window around the announcement day:

$$ASR_{it} = \frac{AR_{it}}{S_i}. \tag{13}$$

Application of SR_{it} instead of R_{it} allows us to compare the results of the analysis for different companies as well for different subperiods because the values of abnormal standardized returns ASR_{it} describe the relative strength of the changes implied by news announcements. Hence, in the presentation of the results we will use ASR_{it} (and their averages $\overline{ASR}_{it}$) rather than AR_{it}. Additionally, to describe the relative strength of the cumulative impact of news under consideration we will report the values of cumulative abnormal standardized returns $CASR_{it}$ computed analogously to (9) with AR_{it} replaced by ASR_{it}.

4 Empirical results

In the first step of the analysis we study the reaction of 5-minute returns over the whole period 2006–2020. This will provide a background for a further, more detailed examination and comparisons. First we will show detailed results of the analysis based on 5-minute returns of EBS whose shares are the most liquid in our sample. Then we will summarize the results for the other companies under consideration.

4.1 EBS

Bad news

Because the most important thing is the reaction of stock prices just before and just after news announcements, in Tables 3 and 4 we present the results of the event study not in the whole event window ($t = -3, \ldots, 12$), but only for $t = -3, \ldots, 3$. The values presented in Table 3 indicate the strong and immediate impact of unexpected bad news from the US economy on EBS returns. Significant means of abnormal returns are mainly observed for $t = 1$, i.e. in the first moment when the impact of new information may be noticed. Changes in EBS share prices are significant (at least at a level of 5%) after the announcements of 8 indicators, namely CCI, DGO, ISM, IJC, NFP, GDP, RS, and cRS. This means that bad news from the US economy is quickly incorporated into stock prices. Furthermore, the means of ASR_1 are mainly significant at a level of 1%. On the other hand, for the other moments of the event window only significance at a level of 5% or 10% is observed. What is also important, in each significant case for $t = 1$ the average $\overline{ASR}_t$ is negative, which confirms that these announcements are seen by investors as bad news. This is in line with our definition of bad news.

A comparison of the averages of ASR_1 shows that the strongest changes in EBS returns are implied by bad news from the labor market (NFP) and bad news about manufacturing (ISM). It should be noted here that both NFP and ISM are released at the beginning of a month (ISM is announced on the first working day, while NFP is announced on first Friday of the month). On average, in the first five minutes after news is released announcements of NFP or ISM values smaller than expected result in an additional drop in EBS returns of about 80% of their standard deviation. These relative values correspond to real additional changes in stock prices of about 0.16% and -0.19% in the first five minutes after ISM and NFP announcements, respectively. When we compare the results of the analysis for $t = 1$ with the other t from the event window we observe that the impact of macroeconomic news announcements is mainly restricted to the first five minutes after news release. The means of ASR_t for $t > 1$ are significant only in a few cases and there is no visible pattern in them. Some values of significant $\overline{ASR}_t$ are positive (which suggests that earlier negative changes have been corrected) while the others are negative (suggesting continuation). Such a continuation of a significant reaction just after news is released is observed in the case of bad news concerning the whole economy included in GDP announcements, where the mean of ASR_2 is also significantly negative.

In order to study the cumulative impact of US macroeconomic news announcements on prices of EBS shares we applied the Kolari-Pynnönen test to cumulative abnormal standardized returns $CASR_t$. The results of this test for $t = 4$, 8 and 12 which describe the cumulative impact of US data after 20, 40, and 60 minutes are reported in the three last columns of Table 3. Comparison of the distributions of ASR_1 and $CASR_t$ shows that a significant change just after news announcements is rarely strong

Table 3: Average abnormal standardized 5-minute returns of EBS for selected t in the event window. Bad news from the US economy

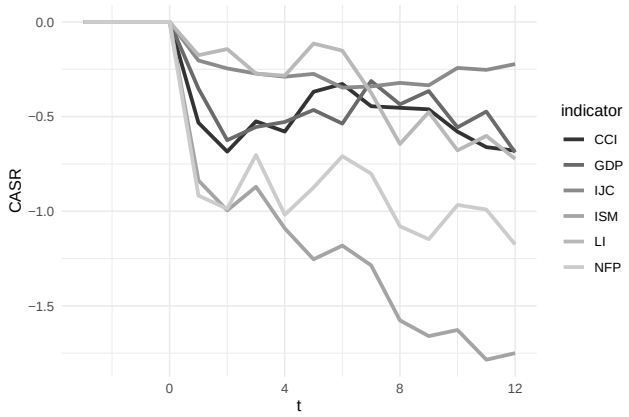
	$\overline{ASR}_t$						$\overline{CASR}_t$		
	$t=-2$	$t=-1$	$t=0$	$t=1$	$t=2$	$t=3$	$t=4$	$t=8$	$t=12$
CCI (79)	-0.04	-0.15	-0.08	-0.53***	-0.15	0.16	-0.58***	-0.45*	-0.68*
CPI (39)	0.10	0.05	0.11	-0.17	0.25*	-0.16	0.01	0.15	0.75
cCPI (41)	0.25	0.01	0.29*	-0.13	0.17	-0.11	-0.12	-0.25	0.38
DGO (81)	0.04	0.00	0.12	-0.35***	0.12	0.10	-0.16	-0.12	-0.10
EHS (80)	-0.20*	-0.04	-0.08	-0.31*	-0.19	0.07	-0.32	-0.12	-0.24
HS (93)	-0.06	0.06	0.12	-0.19	0.14*	0.26**	0.06	0.20	0.58*
IP (74)	-0.01	0.03	0.04	-0.12	-0.08	0.14	-0.05	0.04	-0.27
ISM (67)	0.03	-0.02	-0.05	-0.84***	-0.16	0.12	-1.09***	-1.58***	-1.75***
IJC (337)	-0.05	0.03	-0.05	-0.20***	-0.04	-0.03	-0.29***	-0.32**	-0.22*
LI (64)	0.02	0.03	-0.05	-0.18	0.03	-0.13	-0.28	-0.64*	-0.72**
NHS (80)	-0.19**	0.11	0.05	-0.18	0.04	0.08	-0.04	-0.03	0.22
NFP (85)	0.19	-0.06	0.10	-0.92***	-0.07	0.28	-1.02***	-1.08*	-1.18*
PI (68)	0.15	0.02	0.02	0.12	0.04	0.16	0.28	0.71	0.94
PFBOS (82)	-0.12*	0.01	-0.02	-0.16	-0.06	0.08	-0.17	0.04	0.11
PPI (76)	0.06	0.05	-0.18*	-0.10	-0.07	0.05	-0.20	0.25	0.28
cPPI (72)	0.13	0.11	-0.06	-0.06	0.05	0.07	0.00	0.34	0.38
GDP (68)	0.05	-0.15	0.10	-0.35***	-0.27*	0.07	-0.53**	-0.44	-0.69
RS (85)	-0.01	0.06	-0.09	-0.43**	0.02	0.24	-0.29	-0.08	0.20
cRS (84)	-0.08	0.07	-0.09	-0.44***	-0.08	0.11	-0.58**	-0.23	0.03
All (1035)	-0.03	-0.01	0.02	-0.33***	-0.06	0.07	-0.36***	-0.36***	-0.35***
All without IJC (940)	-0.01	-0.01	0.02	-0.33***	-0.04	0.11**	-0.32***	-0.28***	-0.28**

Notes: *, **, *** – indicates significance of expected value of ASR_t at a level of 10%, 5%, and 1%, respectively. Significance is verified with Kolari-Pynnönen t_{grank} statistics, which has asymptotic t-Student distribution with 35 degrees of freedom.

enough to have a cumulative impact over a longer period. After one hour only bad news regarding ISM has a significant impact at a level of 1% and about LI at a level of 5%. In the case of the other indicators this impact becomes insignificant. An analysis of $\overline{CASR}_t$ for $t > 1$ provides valuable information about the impact of macroeconomic news. To compare the cumulative impact of macroeconomic indicators under consideration on the prices of EBS Figure 2 shows values of $\overline{CASR}_t$ for six of them in a one-hour period after the news release. Figure 2 confirms that the strongest changes take place just after news announcements. After some indicators (GDP, CCI, IJC, LI, NFP) the majority of changes are observed only in the first five minutes. After this time values of $\overline{CASR}_t$ stabilize. On the other hand, in the case of ISM permanent changes in $\overline{CASR}_t$ are observed in the event window after

announcements. This shows the difference in the way new information about different indicators impacts the prices of EBS shares.

Figure 2: $\overline{CASR}_t$ values for EBS in the first 60 minutes after bad news contained in selected indicators



Notes: For each $t \in \{-3, \ldots, 12\}$ this figure presents values of the averages of cumulative abnormal standardized returns $\overline{CASR}_t$ computed on the basis of 5-minute data of EBS corresponding to announcements of bad news regarding CCI, GDP, IJC, ISM, LI, and NFP.

Good news

Changes in the prices of EBS shares after good news from the US economy are similar to those observed after bad news. They are mainly significant just after news releases and this is a significance at a level of 1%. Significant (at least at a level of 5%) means of abnormal returns of EBS are observed in the first period after the announcements of 13 indicators. Only information about inflation (CPI, cCPI, PPI, cPPI), Leading Indicator (LI), and Personal Incomes (PI) is insignificant. Later in the event window, the means of ASR_t are significant only at levels of 5% or 10%. Values of $\overline{ASR}_t$ for $t = 1$ are also the highest among the averages for positive t. This once again indicates that the prices of EBS shares react immediately and significantly to US macroeconomic news. The strongest reaction is implied by good news from the labor market. After the publication of NFP values greater than the expected prices of EBS shares jump by about 170% of the standard deviation of 5-minute returns in the first five minutes. Other announcements that also strongly impact prices are, for example, GDP, ISM, and RS. As we can observe in Table 4 the magnitude of

abnormal standardized returns in the later periods (for $t > 1$) is much smaller than just after the release of news.

Table 4: Average abnormal standardized 5-minute returns of EBS for selected t in the event window. Good news from the US economy

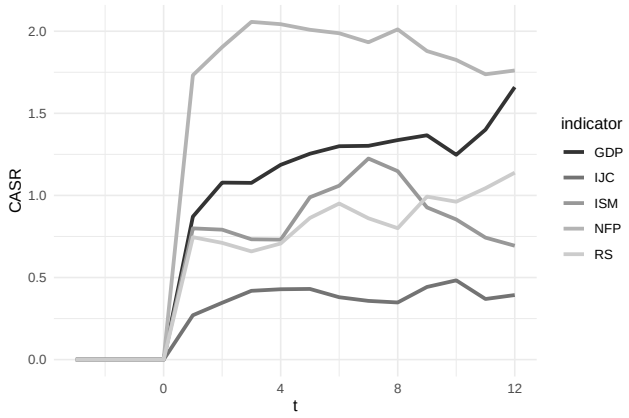
	$\overline{ASR}_t$						$\overline{CASR}_t$		
	$t=-2$	$t=-1$	$t=0$	$t=1$	$t=2$	$t=3$	$t=4$	$t=8$	$t=12$
CCI (87)	0.09	-0.07	0.08	0.51***	0.07	-0.01	0.51*	0.39	0.57
CPI (53)	0.05	0.04	-0.06	-0.27	0.12	0.09	0.11	0.28	0.49
cCPI (60)	0.07	0.11	-0.11	0.01	0.02	-0.03	0.06	0.32	0.47
DGO (82)	0.13	-0.04	-0.02	0.28**	0.11	-0.06	0.17	0.12	0.04
EHS (74)	0.20*	0.04	0.03	0.35**	0.12	0.08	0.40	0.71*	0.55
HS (79)	0.02	0.06	-0.10	0.33***	-0.11	-0.05	0.21**	-0.10	0.17
IP (64)	0.01	0.25*	-0.05	0.45***	0.40**	-0.14	0.57	0.82*	0.49
ISM (79)	0.06	-0.02	0.13	0.80***	-0.01	-0.06	0.73**	1.15***	0.69
IJC (357)	0.06*	0.09*	0.04	0.27***	0.08	0.07**	0.43***	0.35***	0.39***
LI (73)	-0.24**	-0.22**	0.05	0.19*	-0.13	0.16	0.13	-0.02	0.04
NHS (74)	-0.05	-0.23	0.17*	0.32**	-0.22*	0.05	0.00	-0.02	-0.26
NFP (75)	0.19	-0.01	0.06	1.73***	0.17	0.15	2.04***	2.01***	1.76***
PI (59)	0.21	-0.04	0.01	0.12	0.04	0.10	0.13	0.31	0.12
PFBOS (82)	-0.04	0.09	-0.15	0.28**	-0.08	-0.06	0.09	0.02	0.15
PPI (73)	0.02	0.06	0.00	-0.06	-0.05	0.17	-0.06	0.00	-0.05
cPPI (55)	-0.09	0.06	-0.03	-0.11	-0.14	0.30**	0.08	0.30	0.32*
GDP (60)	0.00	0.03	0.11	0.87***	0.21	0.00	1.19***	1.34***	1.66***
RS (69)	0.07**	0.07	-0.01	0.75***	-0.03	-0.05	0.71***	0.80***	1.14***
cRS (58)	0.13*	0.03	-0.04	0.52***	0.15	0.01	0.83***	0.73***	0.95***
All (1014)	0.04**	0.00	0.04*	0.50***	0.08	0.02	0.59***	0.60***	0.58***
All without IJC (893)	0.04	-0.01	0.02	0.51***	0.06	0.02	0.56***	0.61***	0.57***

Notes: *, **, *** – indicates significance of expected value of ASR_t at a level of 10%, 5%, and 1%, respectively. Significance is verified with Kolari-Pynnönen t_{grank} statistics, which has asymptotic t-Student distribution with 35 degrees of freedom.

A comparison with the results in Table 3 shows that good news from the US economy implies more significant changes in stock prices than bad news. Moreover, $\overline{ASR}_t$ values indicate that changes caused by good news are stronger than those that follow bad news. When we compare the cumulative impact of bad and good news we can see that the later have more significant cases after one hour. The means of $CASR_{12}$ are significant after good news concerning IJC, NFP, GDP, RS, and cRS. The strongest changes in stock prices are implied by NFP announcements ($\overline{CASR}_{12} \approx 1.76$) and by

good news concerning GDP ($\overline{CASR}_{12} \approx 1.66$).

Figure 3: $\overline{CASR}_t$ values for EBS in the first 60 minutes after good news contained in selected indicators

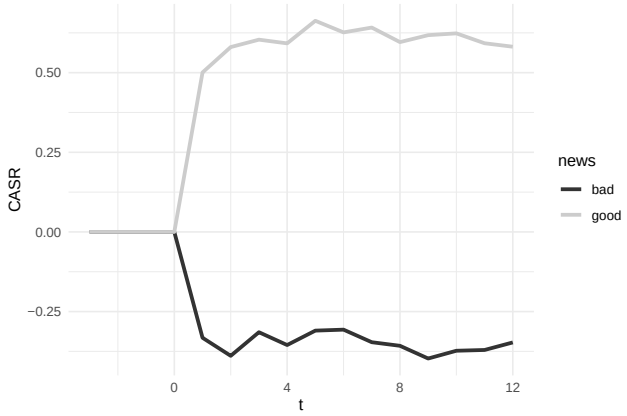


Notes: For each $t \in \{-3, \ldots, 12\}$ this figure presents values of the averages of cumulative abnormal standardized returns $\overline{CASR}_t$ computed on the basis of 5-minute data of EBS corresponding to announcements of good news regarding GDP, IJC, ISM, NFP, and RS.

As in the case of bad news, in Figure 3 $\overline{CASR}_t$ values are presented for indicators which lead to significant cumulative changes. As we can observe in Figure 3 the strongest changes are in the first five minutes after news announcements. Then, $\overline{CASR}_t$ are usually on the same level or increase very slowly. This means that abnormal returns for $t > 1$ are much smaller than for $t = 1$. This pattern was also observed after bad news from the US and this can be seen in Figure 4 where we present the $\overline{CASR}_t$ values after all bad and all good news contained in the announcements under consideration. In the first five minutes after good news the prices of EBS shares increase above the trend by about 60% of the standard deviation of returns. The drop after bad news has a smaller magnitude of about 40% of the standard deviation of 5-minute returns. After this short period (as in Figure 3) $\overline{CASR}_t$ values do not change much.

A comparison of the results from Tables 3 and 4 prompts one to pose a question regarding the asymmetry of changes implied by US macroeconomic news announcements. In order to verify whether good or bad news implies a significantly stronger investor reaction we applied the Kruskal-Wallis test. For each indicator, using this test we compare the distribution of ASR_1 after good news and the distribution of $-ASR_1$ after bad news. If the reactions of investors were symmetrical

Figure 4: $\overline{CASR}_t$ values of EBS in the first 60 minutes after bad and good news announcements



Notes: For each $t \in \{-3, \ldots, 12\}$ this figure presents values of the averages of cumulative abnormal standardized returns $\overline{CASR}_t$ computed on the basis of 5-minute data of EBS corresponding to announcements of bad or good news from the US economy.

these distributions would not differ significantly. The results of the Kruskal-Wallis tests show that significant (at a level of 5%) asymmetry of abnormal returns is observed only just after announcements of NFP and GDP. In both cases the reaction after good news is significantly stronger than the reaction after bad news from the US economy. For the other indicators ASR_1 after good news and $-ASR_1$ after bad news have similar distributions.

Standardized news

In the above analysis we classified events into clusters based only on the difference between the announced value of an indicator and its expectation. In order to verify the impact of the strength of new information on the reaction of investors on the VSE we will consider standardized news. Like Balduzzi et al. (2001) and Andersen et al. (2003) we divide the difference between the announced and expected value of an indicator by the standard deviation of these differences. More precisely standardized news included in l-th announcements of k-th indicator (S_{lk}) is given by formula:

$$S_{lk} = \frac{A_{lk} - E_{lk}}{\widehat{\sigma}_k},$$

where:
A_{lk} –l-th announced value of k-th indicator,

E_{lk}- expected value of l-th announcement of k-th indicator,
$\widehat{\sigma}_k$- standard deviation of differences $A_{lk} - E_{lk}$ computed for k-th indicator.
In this definition the standard deviation $\widehat{\sigma}_k$ is computed on the basis of announcements from January 2006 up to March 2020, due to the very volatile behavior of investors caused by the COVID-19 pandemic in the following months of 2020.
In order to verify the impact of the difference between the announced and expected value of indicators we repeated the above analysis taking into account only announcements with a very high such difference. More precisely, we consider only announcements with $|S_{lk}| > 0.5$. The results of this analysis are presented in Tables 5 and 6.

Table 5: Average abnormal standardized 5-minute returns of EBS in a part of event window when bad news from the US economy is announced. Cases with $|S_{ik}| > 0.5$

	$\overline{ASR}_t$							$\overline{CASR}_t$		
	$t=-3$	$t=-2$	$t=-1$	$t=0$	$t=1$	$t=2$	$t=3$	$t=4$	$t=8$	$t=12$
CCI (33)	0.02	-0.08	-0.08	-0.25*	-0.46***	-0.19	0.04	-0.57*	-0.37	-0.61
CPI (39)	0.18	0.10	0.05	0.11	-0.17	0.25*	-0.16	0.01	0.15	0.75
cCPI (41)	0.14	0.25	0.01	0.29*	-0.13	0.17	-0.11	-0.12	-0.25	0.38
DGO (43)	-0.08	-0.02	0.00	0.07	-0.70***	0.03	0.22	-0.51***	-0.32**	-0.11
EHS (27)	0.17	-0.28**	0.16	0.06	-0.53**	-0.01	0.22	0.03	-0.03	0.02
HS (55)	-0.01	-0.11	0.10	0.17	-0.34	0.11	0.16	-0.15	-0.01	0.43
IP (63)	0.09	0.02	0.03	0.07	-0.18	-0.04	0.16	-0.12	-0.07	-0.23
ISM (23)	-0.31**	0.12	-0.22	-0.07	-1.54***	-0.21	0.41***	-1.60***	-1.46	-1.45
IJC (179)	0.02	-0.04	-0.05*	-0.04	-0.44***	-0.14	-0.02	-0.55***	-0.62***	-0.48***
LI (18)	-0.04	-0.21	0.14	-0.32	-0.50	-0.19	0.16	-0.74	-0.59	-1.07
NHS (18)	0.14	-0.30*	0.21	0.02	-0.50***	-0.33	0.38	-0.62**	-1.07**	-1.09*
NFP (37)	-0.20*	0.12	0.05	-0.02	-1.19***	-0.05	0.27	-1.37**	-1.89*	-2.00
PI (28)	0.01	0.21	0.14	0.01	0.37	0.00	0.28	0.75	0.94	1.20
PFBOS (47)	-0.06	-0.21**	0.07	0.03	-0.23	-0.09	0.15	-0.07	0.26	0.41
PPI (40)	-0.19*	0.03	0.24	-0.01	-0.29**	-0.10	-0.12	-0.49*	-0.02	-0.14
cPPI (43)	0.02	0.02	0.09	-0.12	-0.28	0.28	0.03	-0.09	0.49	0.65
GDP (37)	0.19*	0.10	-0.27**	0.20	-0.62***	-0.28**	0.08	-0.96***	-0.84	-1.02
RS (54)	-0.01	-0.10	0.07	-0.11	-0.74***	-0.07	0.21	-0.70**	-0.44	-0.01
cRS (47)	-0.12	0.03	0.12	-0.20	-0.91***	-0.18	0.06	-1.32***	-0.89**	-0.53
All (631)	0.00	-0.02	0.01	0.03*	-0.41***	-0.05	0.12***	-0.39***	-0.34***	-0.26***
All without IJC (532)	0.00	-0.01	0.04	0.03*	-0.42***	-0.04	0.15***	-0.38***	-0.24**	-0.17*

Notes: *, **, *** – indicates significance of expected value of ASR_t at a level of 10%, 5%, and 1%, respectively. Significance is verified with Kolari-Pynnönen t_{grank} statistics, which has asymptotic t-Student distribution with 35 degrees of freedom.

Table 6: Average abnormal standardized 5-minute returns of EBS in a part of event window. Good news from the US economy

	$\overline{ASR}_t$							$\overline{CASR}_t$		
	$t=-3$	$t=-2$	$t=-1$	$t=0$	$t=1$	$t=2$	$t=3$	$t=4$	$t=8$	$t=12$
CCI (42)	-0.27**	0.27*	0.06	-0.01	0.28***	0.12	-0.06	0.31	0.37	0.59
CPI (53)	-0.06	0.05	0.04	-0.06	-0.27	0.12	0.09	0.11	0.28	0.49
cCPI (60)	-0.14*	0.07	0.11	-0.11	0.01	0.02	-0.03	0.06	0.32	0.47
DGO (38)	-0.06	0.10	-0.21	0.10	0.17	0.18	-0.18	-0.02	0.05	-0.21
EHS (27)	0.17	0.20	-0.06	0.02	0.37	-0.25	0.02	0.12	0.02	0.18
HS (39)	-0.05	0.14*	0.19	-0.22	0.42	-0.16	-0.01	0.49***	0.07	0.15
IP (44)	0.22	0.01	0.22*	-0.19	0.34**	0.46	-0.16	0.48	0.63	0.07
ISM (36)	-0.06	0.22	-0.12	0.07	0.67***	0.10**	0.12	0.75*	1.24**	1.36*
IJC (178)	0.00	0.12*	0.12**	0.05	0.36***	-0.01	0.09	0.42***	0.32**	0.49***
LI (36)	-0.06	-0.31	-0.18	-0.03	0.12***	0.16	0.09*	0.16	-0.16	-0.05
NHS (23)	0.04	0.03	-0.17	-0.03	0.25	-0.54***	-0.01	-0.31*	-0.52*	-0.75
NFP (25)	-0.01	0.28*	0.11	-0.14	2.32***	0.51*	0.25	2.97***	2.80***	2.41***
PI (28)	0.02	0.05	-0.29	-0.05	0.26	0.24	-0.18	0.00	-0.13	-0.60
PFBOS (48)	0.01	-0.15	0.25*	-0.28**	0.34*	-0.01	0.03	0.30	0.19	0.23
PPI (44)	-0.15	0.01	0.15	-0.02	-0.03	-0.12	0.26	-0.07	-0.07	-0.19
cPPI (32)	0.07	0.04	0.13	0.10	-0.12	-0.14	0.32	0.09	0.18	0.40
GDP (32)	-0.01	-0.12	-0.01	0.09	1.25***	0.16	-0.02	1.30***	1.51**	1.58***
RS (39)	0.19*	-0.03	0.10	0.01	0.65***	0.01	-0.12	0.68***	0.73**	1.25***
cRS (28)	0.16	0.08	0.03	-0.21	0.75***	0.12	-0.12	0.91***	0.64	0.81*
All (621)	-0.01	0.07**	0.04	-0.01	0.46***	0.10	0.03	0.55***	0.53***	0.58***
All without IJC (520)	-0.03	0.06**	0.01	-0.06	0.46***	0.11	0.02	0.54***	0.56***	0.57***

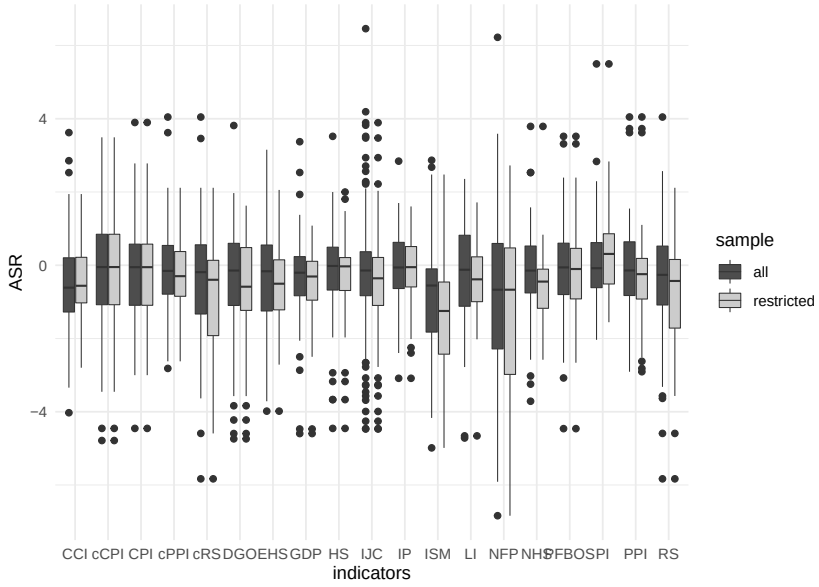
Notes: *, **, *** – indicates significance of expected value of ASR_t at a level of 10%, 5%, and 1%, respectively. Significance is verified with Kolari-Pynnönen t_{grank} statistics, which has asymptotic t-Student distribution with 35 degrees of freedom.

Restricting the analysis only to very surprising announcements reduces the sample of the events under consideration. We should note that this fact might impact the power of the Kolari-Pynnönen test. Only in the case of CPI and cCPI announcements is the sample of events not reduced due to the very large number of announcements in line with consensus. Hence, in the comparison of the results in Tables 5 and 6 with the previous results we will not mention these indicators.

In Table 5 we observe that for the majority of indicators under consideration restriction of the analysis only to very bad news increases the strength of the impact. For almost all the indicators values of $\overline{ASR}_1$ are smaller than in Table 3. The only exceptions are announcements of CCI and PI, but in these cases both averages (for all announcements and in the restricted sample) are insignificant. The strongest

changes in EBS returns are caused this time by bad news regarding ISM. Restricting the analysis increases the number of cases with a significant average of abnormal returns. In Table 5 a significant impact at least at a level of 5% is observed after three additional macroeconomic indicators: EHS, NHS, and PPI. However, restricting the analysis leads to a very strong reduction in the sample of events: from 80 to 27 for EHS and from 80 to 18 for NHS.

Figure 5: Box-plots of distribution of ASR_1 of EBS after bad news ("all") and after very bad news announcements ("restricted")

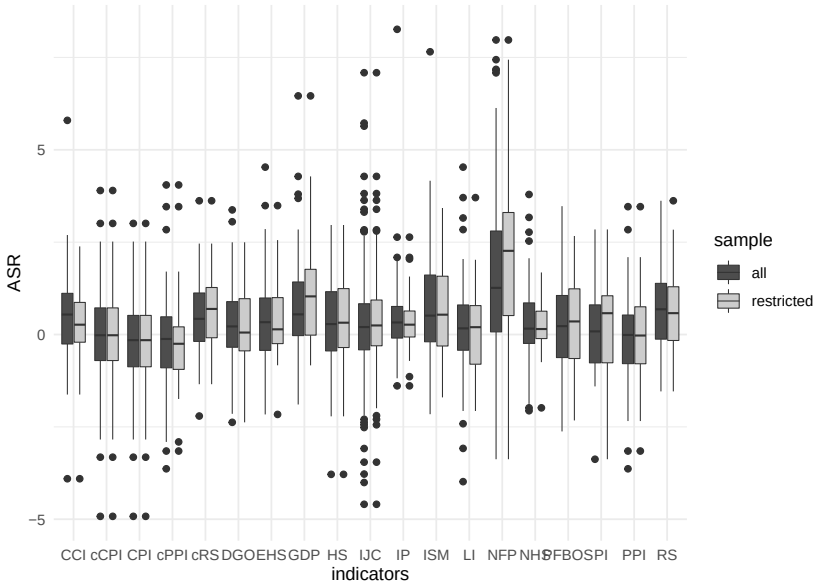


Notes: For each indicator under consideration this figure presents box-plots of values of abnormal standardized returns ASR_1 of EBS in first five minutes after all bad news announcements and after very bad news announcements (with $|S_{ik}| > 0.5$).

In order to verify whether announcements of very bad news lead to significantly stronger changes in EBS returns than in the case of the whole sample of bad news we performed a bootstrap analysis. For each indicator, from the whole sample of ASR_1 for bad news we randomly generated 1000 subsamples of a length equal to the number of announcements of very bad news. Then we computed the percentage of averages $\overline{ASR_1}$ smaller than the average for very bad news only. This bootstrap procedure shows that the restriction of the analysis only to very bad news gives a significantly stronger reaction (at the 5% level) only after announcements of EHS, ISM, IJC, and

cRS. In the case of the other macroeconomic indicators the average $\overline{ASR}_1$ after very bad news does not differ from the other averages computed on the basis of sets of abnormal standardized returns of the same length.

Figure 6: Box-plots of distribution of ASR_1 of EBS after good news ("all") and after very good news announcements ("restricted")



Notes: For each indicator under consideration this figure presents box-plots of values of abnormal standardized returns ASR_1 of EBS in first five minutes after all good news announcements and after very good news announcements (with $|S_{ik}| > 0.5$).

Restriction of the analysis also changes the results of cumulated impact, but the conclusions are mixed. For the majority of cases the $\overline{CASR}_{12}$ values in Table 5 are lower than the respective values in Table 3. This indicates a stronger impact of news under consideration over the longer period. However, in Table 5 there is only one case with a significant average of cumulated abnormal returns (IJC), whereas in Table 3 there are two such cases (IJC and LI). The box-plots presented in Figure 5 allow a more precise comparison of the distribution of ASR_1 with and without the restriction. In the case of good news the results of the analysis of the restricted sample are the opposite. For 8 indicators (CCI, DGO, IP, ISM, LI, NHS, cPPI, and RS) the $\overline{ASR}_t$ values in Table 6 are smaller than in Table 4, indicating a weaker impact of news announcements. Furthermore, restricting the analysis reduces the number of

significant changes in the first five minutes after news announcements from 13 to 9. Insignificant ASR_1 averages are now observed after DGO, EHS, NHS, and PFBOS. However, the reduction of the sample should also be taken into account. For example, in the case of EHS the number of events under consideration decreases from 74 to 27, for NHS from 74 to 23. On the other hand, the number of NFP announcements reduces from 75 to 25, but the average remains significant. Differences between distributions of ASR_1 for the whole sample and for very good news only are presented in Figure 6. A bootstrap analysis performed analogously, as in the case of very bad news, confirms these results. For all indicators under consideration the average $\overline{ASR}_t$ after very good news is insignificant when compared to the averages computed on the basis of other good news.

Restricting the sample also impacts the results obtained for cumulated abnormal returns. For the whole sample one hour after news announcements $\overline{CASR}_{12}$ are significant for IJC, NFP, GDP, RS, cRS, but when the analysis is performed only for very good news the changes after cRS become insignificant. Additionally, the reduction leads to smaller $\overline{CASR}_{12}$ values after GP and cRS announcements. However, after the other indicators we observe higher average values. The highest $\overline{CASR}_{12}$ value follows very good news from the labor market included in NFP announcements (the average increases from 1.76 to 2.41).

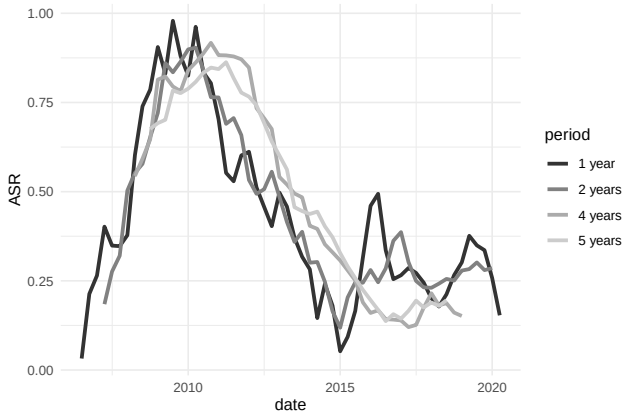
Changes in reaction strength

The main part of the empirical study in this paper concerns changes in the strength of the investors' reaction to US macroeconomic news over the last 15 years. To do this, we compare results of an event study analysis carried out in various subperiods. These subperiods should be long enough to include a suitable number of macroeconomic announcements. On the other hand, it is better to take the shortest possible subperiods into account because this gives more accurate results. Finally, as a compromise, we perform event study analysis in 1-, 2-, 4-, and 5-year windows shifted every quarter. The first of such windows begins in January 2006, while the last one ends in June 2020. The procedure described above is flexible enough to give us an appropriate description of changes in EBS returns in the reaction to US macroeconomic news announcements.

In general, the analysis presented in the previous subsections shows that changes after bad and good news from the US are of almost the same magnitude and asymmetry occurs only after two indicators. Hence, to increase the number of events in the windows we take both types of unexpected news into account together. To do this, as in the analysis of asymmetry, we multiply abnormal returns corresponding to bad news by -1. As a result, all abnormal returns modified in this way ($MASR_t$) should move in one direction after news announcements, i.e. they should increase.

The results of these event study analyses in subperiods are summarized in Figure 7 where we present the $\overline{MASR}_1$ averages of modified abnormal standardized returns

Figure 7: Averages of modified abnormal standardized returns ($\overline{MASR_1}$) of EBS over various windows



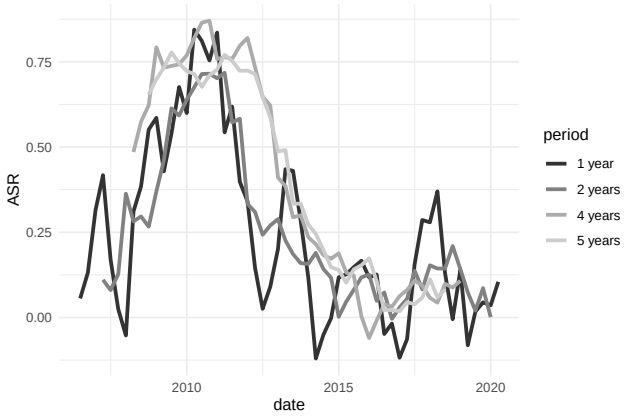
Notes: Modified abnormal standardized returns $MASR_1$ are equal to ASR_1 after good news announcements and are equal to $-ASR_1$ after bad news announcements. Averages ($\overline{MASR_1}$) of abnormal standardized returns of EBS in the first five minutes after US macroeconomic news announcements were computed in windows of various lengths. Each window was shifted every three months to cover the whole period 2006–2020. On the X axis we marked the centers of the windows.

computed for all announcements in each window. As we observe from Figure 7 the strength of changes in EBS share prices implied by US macroeconomic news announcements varies over the period under consideration. The highest values of $\overline{MASR_1}$ occur in the period just after the global financial crisis 2007–2009 and they are very close to one standard deviation of 5-minute returns. Then, since 2010–2011 the reaction of investors just after unexpected news from the US economy has weakened. However, at the end of the period the decreasing trend of the averages inverses. This indicates increased importance of information from the US. In addition to the value of the average its significance matters. In general, averages $\overline{MASR_1}$ are significant at least at a level of 5% in almost all subperiods. There are some cases of insignificance around 2017, but they occur mainly when the analysis is performed in 1-year windows. Since then the impact of announcements under consideration has again been significant.

Changes in the magnitude of average abnormal returns are observed not only when all announcements are considered jointly, but also for each indicator separately. As an example, in Figure 8 we present $\overline{MASR_1}$values after IJC announcements. The pattern for the other indicators is similar, but due to the smaller number of events the analysis must be performed only in 4- or 5-year windows.

An analysis of the cumulated values of modified abnormal standardized returns

Figure 8: Averages of modified abnormal standardized returns ($\overline{MASR_1}$) of EBS over various windows after IJC announcements

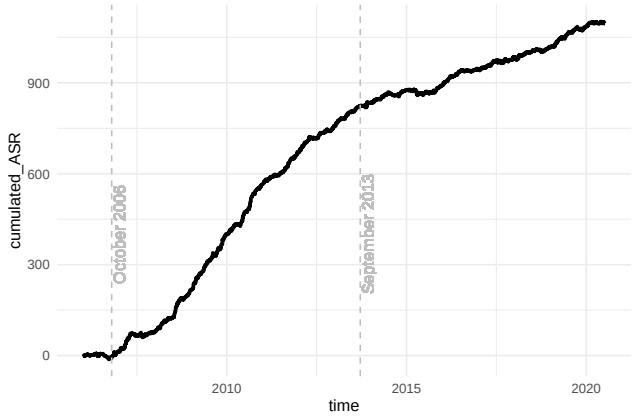


Notes: Modified abnormal standardized returns $MASR_1$ are equal to ASR_1 after good news announcements and are equal to $-ASR_1$ after bad news announcements. Averages ($\overline{MASR_1}$) of abnormal standardized returns of EBS in the first five minutes after US macroeconomic news announcements were computed in windows of various lengths. Each window was shifted every three months to cover the whole period 2006–2020. On the X axis we marked the centers of the windows.

provides us with another valuable piece of information about changes in the strength of investors' reactions on the VSE to US macroeconomic news announcements. More precisely, we sort all the announcements relative to time from the oldest to the newest. Then we cumulate the corresponding values of modified abnormal standardized returns $MASR_1$ just after these announcements. For a given time t between January 1, 2006 and June 31, 2020 the value of cumulated modified abnormal standardized returns $CMASR_t$ equals the sum of $MASR_1$ for all announcements of unexpected US macroeconomic news between January 1, 2006 and time t. If the reaction of investors is in line with the difference between the announced and expected value of an indicator, the value of $MASR_1$ should be positive for good, as well as for bad news. Hence, we expect values $CMASR_t$ to grow (see Figure 9).

The slope of the $CMASR_t$ graph depends on the strength with which the new information affects the prices of EBS shares. When announcements imply greater changes in stock prices $CMASR_t$ values grow faster and the slope of the graph increases. On the other hand, when the impact of news weakens, the slope decreases and the graph flattens out. The main advantage of analyzing $CMASR_t$ rather than $\overline{MASR_1}$ values is their flexibility. Using $CMASR_t$ we are able to analyze all the announcements one by one and identify changes in their slope. In Figure 9 we can distinguish three main parts of the graph. They are approximately marked by vertical

Figure 9: Values of cumulated modified abnormal standardized returns $CMASR_t$ of EBS



Notes: For a given time t between January 1, 2006 and June 31, 2020 the value of cumulated modified abnormal standardized returns $CMASR_t$ equals the sum of $MASR_1$ for all announcements of unexpected US macroeconomic news between January 1, 2006 and time t. Modified abnormal standardized returns $MASR_1$ are equal to ASR_1 after good news announcements and are equal to $-ASR_1$ after bad news announcements.

dashed lines. In the first part the graph is almost horizontal. This means that changes in EBS returns just after US news announcements are very small or $MASR_t$ values are cancelled out. Then, at the end of 2006, $CMASR_t$ values start to rise. In the figure we highlighted October 2006 because the first signs of a housing crisis in the US appeared in the third quarter of 2006; property prices stopped rising and the speculative bubble on the real estate market burst. The very steep slope of the graph is especially visible from January to April 2007. Then the graph is almost vertical until August 2007. Since then we have observed an increased impact of US macroeconomic news on EBS prices. This period lasts until at least 2013. After that the importance of these messages gradually decreases. As an example, in Figure 9 we marked September 2013 when the Fed decided to hold off on scaling back its bond-buying program. Additionally, in 2013 US stock market indices returned to the level from before the crisis. This was one of the results of the bull market observed in 2013 all around the world. For example, S&P500 increased about 30%, DAX – 25%, FTSE100 – 18%, NIKKEI – 57%.

4.2 Other companies from the ATX

Tables 7 and 8 present the values of mean abnormal standardized returns $\overline{ASR}_t$ computed for the first 5-minute period just after news announcements for bad (Table 7) or good (Table 8) unexpected news included in announcements of US macroeconomic indicators described in Section 3.1. Together with the values of $\overline{ASR}_t$ we report the results of the Kolari-Pynnönen generalized rank test. In addition to the means for single indicators, in Table 7 and 8 we present results of the event study analysis for all bad and all good news (rows "All" and "All without IJC").

The results in Tables 7 and 8 show a strong and significant reaction of the stock prices of the largest companies listed on the VSE to US macroeconomic news announcements. However, the strength of the change and its significance depends on both the stock and announced indicator.

In the case of bad news the largest number of significant changes (at a level of at least 5%) is observed after announcements of ISM (10 stocks), NFP (9 stocks), cRS (9), and CCI (8 cases). On the other hand, announcements of unexpected bad news contained in the value of PFBOS and HS imply no significant changes in the prices of stocks under consideration.

When we take the reaction of individual stocks into account we can also see differences in the number of significant reactions. The largest number of significant changes implied by US macroeconomic news announcements is observed in the case of WIE (after 11 indicators), TKA, RBI, VER, and VOE. On the other hand, only one such change is observed in the case of EVN (after LI) and MMK (after NHS) 5-minute returns.

The strongest reaction of stock prices (measured by the value of $\overline{ASR}_1$) is in general implied by bad news from the labor market. The highest $\overline{ASR}_1$ (in absolute value) are observed after NFP announcements: -0.92 for EBS and -0.84 for RBI. Besides that, a very strong reaction is observed in the prices of EBS after bad news contained in ISM ($\overline{ASR}_1 \approx -0.84$). These $\overline{ASR}_1$ values mean that after bad news 5-minute returns drop additionally up to about 80% of their standard deviation.

The values of $\overline{ASR}_1$ in the two last rows of Table 7 give general information about the strength of the reaction of the stock prices of each company to bad news from the US economy. The lowest $\overline{ASR}_1$ values (and the strongest reaction) is observed in the case of EBS, RBI, and VOE. A comparison with values from Table 2 indicates that they are also the most heavily traded stocks.

An analysis of the results in Table 8 leads to similar conclusions. The largest number of significant changes is observed after unexpected good news included in the announcements of ISM (for 11 stocks), NFP (11), GDP (10), and CCI (9) announcements. Three of these indicators (ISM, NFP, and CCI) were also mentioned when the impact of bad news was analyzed. In contrast to Table 7 insignificant changes are observed after good news regarding LI and CPI. When we take changes in the stock prices of an individual company into account we observe that, as before,

Table 7: Average abnormal standardized returns in the first five minutes after bad news from the US economy

	ANDR	EBS	EVN	MMK	OMV	POST	RBI	SBO	TKA	VER	VIG	VOE	WIE
CCI (79)	-0.54**	-0.53***	-0.17	-0.07	-0.46***	0.10	-0.81***	0.00	-0.26**	-0.27**	-0.15*	-0.71***	-0.56***
CPI (39)	-0.06	-0.17	0.04	0.15	-0.33	-0.10	-0.14	-0.33**	-0.17	-0.48***	-0.15	-0.33*	-0.63**
cCPI (41)	-0.17	-0.13	-0.03	0.06	-0.51**	-0.13	-0.35**	-0.37*	-0.05	-0.37**	-0.33	-0.32	-0.51**
DGO (81)	-0.06	-0.35***	0.14*	-0.07	-0.24	-0.14**	-0.11	0.01	-0.21**	-0.14	-0.46***	-0.19*	-0.23***
EHS (80)	-0.28**	-0.31*	-0.05	0.08	-0.56***	-0.19***	-0.39***	-0.06	-0.46***	-0.01	-0.09	-0.40**	-0.17
HS (93)	0.10	-0.19	0.04	-0.01	-0.10	-0.08	0.06	-0.11	-0.05	-0.11	-0.15*	-0.02	-0.17
IP (74)	-0.29*	-0.12	0.03	-0.07	-0.34***	-0.03	-0.24*	-0.17*	0.00	-0.21	-0.25**	-0.37***	-0.21**
ISM (67)	-0.68***	-0.84***	0.04	0.00	-0.65***	-0.13	-0.46***	-0.39***	-0.45***	-0.47***	-0.31**	-0.57***	-0.32**
IJC (337)	-0.17***	-0.20***	0.01	-0.08	-0.05	-0.08*	-0.13**	-0.09*	-0.11***	-0.16**	-0.05**	-0.14**	-0.02
LI (64)	-0.11	-0.18	0.31**	0.06	0.00	-0.22*	-0.13	-0.02	-0.02	0.00	-0.19	0.21*	-0.12
NHS (80)	0.00	-0.18	-0.07	-0.15**	0.01	-0.23***	-0.17	-0.02	0.07	-0.07	-0.09	-0.19**	-0.28***
NFP (85)	-0.49***	-0.92***	-0.18	-0.09	-0.52***	-0.19	-0.84***	-0.33**	-0.31**	-0.49***	-0.57***	-0.56*	-0.80***
PI(68)	0.05	0.12	-0.23	-0.02	0.11	0.10	0.18	0.13	0.05	0.34***	0.09	0.12	0.10
PFBOS (82)	-0.11	-0.16	-0.13	-0.13	-0.03	-0.05	0.01	-0.01	-0.12	-0.06	-0.05	-0.07	0.03
PPI (76)	0.04	-0.10	-0.04	-0.08	-0.11	0.13	-0.06*	0.03	-0.25**	-0.14	-0.12	0.00	-0.22**
cPPI (72)	-0.02	-0.06	-0.03	-0.13*	-0.10	0.00	0.06	-0.22	-0.18**	-0.15*	0.00	-0.04	-0.10
GDP (68)	-0.34***	-0.35***	-0.09	-0.04	-0.30*	-0.02	-0.45***	-0.28	-0.34***	-0.28**	-0.40***	-0.50**	-0.18
RS (85)	-0.22	-0.43**	0.01	-0.08	-0.08	-0.28	-0.38**	-0.39***	-0.10**	-0.14*	-0.44***	-0.45***	-0.40***
cRS (84)	-0.29	-0.44***	-0.03	0.02	-0.18**	-0.32**	-0.36**	-0.34***	0.01	-0.32***	-0.41***	-0.47***	-0.34***
All (1035)	-0.25***	-0.33***	0.01	-0.06**	-0.23***	-0.08**	-0.30***	-0.13***	-0.16***	-0.16***	-0.21***	-0.31***	-0.26***
All without IJC (940)	-0.24***	-0.33***	-0.01	-0.05*	-0.26***	-0.08**	-0.32***	-0.12***	-0.17***	-0.17***	-0.26***	-0.31***	-0.28***

Notes: *, **, *** – indicates significance of expected value of ASR_t at a level of 10%, 5%, and 1%, respectively. Significance is verified with Kolari-Pynnönen t_{grank} statistics, which has asymptotic t-Student distribution with 35 degrees of freedom.

Table 8: Average abnormal standardized returns in the first five minutes after good news from the US economy

	ANDR	EBS	EVN	MMK	OMV	POST	RBI	SBO	TKA	VER	VIG	VOE	WIE
CCI (87)	0.45***	0.51***	0.03	-0.13*	0.32**	0.22***	0.33***	0.09	0.02	0.22***	0.25***	0.33**	0.41***
CPI (53)	-0.06	-0.27	0.01	-0.06	0.12	-0.20	0.06	-0.28	0.01	0.25*	-0.11*	-0.02	0.05
cCPI (60)	0.18	0.01	-0.04	-0.03	0.20	0.03	-0.01	0.03	0.19	0.11	-0.11	0.21**	0.17***
DGO (82)	0.06	0.28**	0.15**	0.00	-0.09	0.00	0.08	-0.08	0.15	0.15*	0.16**	0.19	0.05
EHS (74)	0.32**	0.35**	0.06	0.04	0.17	0.25***	0.23**	0.01	0.22	0.06	0.19**	0.56***	0.29**
HS (79)	0.27**	0.33***	-0.04	-0.01	0.11	0.10	0.36	-0.15	0.04	-0.09	0.13**	0.02	0.18
IP (64)	0.04	0.45***	0.04	0.09**	0.15	0.16	0.33	0.25	0.23	0.24*	0.18*	0.42***	0.17
ISM (79)	0.42***	0.80***	0.07	0.28***	0.66***	0.17	0.77***	0.57***	0.43***	0.26**	0.39**	0.87***	0.60***
IJC (357)	0.19***	0.27***	0.01	-0.10	0.15***	0.04	0.22***	0.04	0.04	0.27***	0.00	0.24***	0.18***
LI (73)	0.21*	0.19*	0.13*	0.20*	-0.10	0.11	0.11	0.16	0.10	0.09	0.12	0.22*	0.06
NHS (74)	0.18	0.32**	-0.04	0.01	0.45***	0.23***	0.38*	-0.02	0.12	0.09	0.29	0.19	0.53***
NFP (75)	0.84***	1.73***	0.09	0.03	0.94***	0.51***	1.22***	0.72***	0.77***	0.57***	0.98***	1.35***	0.92***
PI (59)	0.01	0.12	0.13	0.17***	0.03	0.07	0.15	-0.01	-0.04	0.03	0.08	-0.02	0.16**
PFBOS (82)	0.00	0.28**	0.00	0.24**	0.11*	-0.08	0.24**	0.04	0.02	-0.04	-0.03	0.37***	0.12
PPI (73)	-0.18	-0.06	-0.13	-0.13	-0.18	-0.41*	-0.25***	-0.49***	-0.13**	-0.14**	-0.19	-0.07	-0.11*
cPPI (55)	-0.12	-0.11	-0.16**	0.01	-0.15	-0.47***	-0.29**	-0.40***	0.00	-0.17*	-0.06	-0.02	-0.21**
GDP (60)	0.40***	0.87***	-0.23***	0.20**	0.32**	0.11	0.65***	0.00	0.34***	-0.07	0.30**	0.54***	0.46**
RS (69)	0.33***	0.75***	0.14	0.11	0.24	-0.23	0.63***	-0.15	0.11	0.22*	0.34***	0.51***	0.29**
cRS (58)	0.30***	0.52***	0.20	0.05	0.34**	-0.16	0.55***	-0.05	0.01	0.31**	0.25	0.56***	0.32***
All (1014)	0.29***	0.50***	0.06*	0.05***	0.27***	0.13***	0.38***	0.10***	0.18***	0.24***	0.22***	0.41***	0.30***
All without IJC (893)	0.27***	0.51***	0.04	0.10***	0.29***	0.11***	0.39***	0.10**	0.20***	0.16***	0.24***	0.43***	0.31***

Notes: *, **, *** – indicates significance of expected value of ASR_t at a level of 10%, 5%, and 1%, respectively. Significance is verified with Kolari-Pynnönen t_{grank} statistics, which has asymptotic t-Student distribution with 35 degrees of freedom.

Table 9: P-values in Kruskal-Wallis test that verify the asymmetry of changes just after unexpected news announcements

	No. of significant asymmetries	AGR	EBS	EVN	MMK	OMV	POST	RBI	SBO	TKA	VER	VIG	VOE	WIE
CCI	2	0.521	0.815	0.988	0.510	0.268	**0.014**	**0.036**	0.527	0.511	0.835	0.260	0.149	0.643
DGO	2	0.102	0.955	**0.006**	0.276	**0.006**	0.136	0.884	0.681	0.976	0.873	0.178	0.437	0.100
ISM	1	0.748	0.474	0.629	**0.032**	0.892	0.336	0.072	0.740	0.967	0.157	0.908	0.656	0.433
LI	2	0.731	0.714	**0.023**	0.219	0.962	0.898	0.707	0.500	0.698	0.300	0.836	**0.017**	0.704
NHS	1	0.612	0.483	0.368	0.545	**0.016**	0.955	0.492	0.731	0.879	0.734	0.399	0.806	0.273
NFP	4	**0.014**	**0.036**	0.706	0.603	0.205	0.079	0.164	0.229	**0.037**	0.431	0.110	**0.037**	0.278
PI	4	0.538	0.442	**0.009**	**0.028**	0.761	0.406	0.105	0.763	0.790	**0.042**	0.198	0.713	**0.011**
PPI	4	0.542	0.298	0.130	0.177	0.135	0.353	**0.013**	**0.023**	**0.003**	0.064	0.403	0.915	**0.026**
cPPI	5	0.313	0.187	0.140	0.367	0.249	0.083	**0.042**	**0.001**	**0.041**	**0.029**	0.950	0.984	**0.048**
GDP	1	0.432	**0.038**	0.125	0.068	0.706	0.407	0.434	0.730	0.875	0.139	0.702	0.573	0.480

Notes: In this table we present p-values in Kruskal-Wallis tests only for indicators for which the null hypothesis was rejected at least once.

a very high number of significant means of abnormal returns is observed for WIE, VOE, and RBI. However, the largest number of significant averages of ASR_1 after good news is in the case of EBS. At the other extreme are the prices of EVN, SBO, and TKA, where only 3-4 significant changes occur.
Similarly to bad news, the strongest reaction of investors on the VSE is caused by the announcements of NFP. $\overline{ASR}_1$ is about 1.73 for EBS, 1.33 for VOE, and 1.22 for RBI. These numbers are much higher in absolute value than the respective $\overline{ASR}_1$ after bad news. This indicates the possibility of asymmetry in the reaction to US macroeconomic news announcements. However, a simple comparison of absolute values of the averages $\overline{ASR}_1$ shows that good news from the US economy leads to a stronger reaction of stock prices only in about 55% of cases. Hence, the Kruskal-Wallis test was used for formal verification. Its results are reported in Table 9. Significant asymmetry is only noticeable in a few cases. The largest number of asymmetric reactions occurs after announcements of cPPI, NFP, PI, and PPI. A comparison of the results in Tables 7–9 indicates that asymmetry is usually only observed when changes following one type of news (bad or good) are significant. When changes after both types of announcements are insignificant then the null hypothesis in Kruskal-Wallis test is usually not rejected.
The last two rows of Table 8 show that the strongest reaction after good news is observed in the stock prices of EBS, RBI, and VOE. These are the same companies that react most strongly to bad news. From this we can conclude that the strength of changes in stock prices is mainly related to liquidity of the stock. Confirmation of this conjecture is given by the fact that the weakest reaction for both bad and good news is observed in the case of EVN and MMK, which have the lowest number of trades in Table 2.

Cumulative impact of news announcements

Tables 10 and 11 present the results of the analysis of the cumulative impact of US macroeconomic news announcements. More precisely, they contain values of the length of the period from news announcements with significant expected values of CAR_t, however, when we are only interested in the significance of news an impact analysis of returns and standardized returns give the same results. For example, the value of 15 for ANDR after CCI announcements in the top left corner of Table 5 means that after CCI announcements the means of CAR_1, CAR_2, and CAR_3 are significant. When the mean of CAR_1 is insignificant we alternatively measure the length of the uninterrupted significant cumulative impact of the event starting from $t = 2$. Its length is presented in parentheses. When both means of CAR_1 and CAR_2 are insignificant a value of 0 is reported.
In Table 10 we observe that the strongest cumulative impact is implied by CCI values lower than expected: for OMV, RBI, VOE and WIE cumulative abnormal returns are significant up to 60 minutes after news announcements. In the case of bad news from NFP and ISM two such long periods are observed. We can also observe cases of

delayed significant reaction. For example, for VOE there are four values in parentheses indicating that the cumulative reaction is significant only from $t = 2$. However, a comparison with the results from Table 3 indicates that changes in returns of VOE in the first 5-minute period are significant, but at a level of 10%. Nevertheless, these results show that in some cases new information needs more time to be significantly incorporated into prices.

Table 10: Length of significant cumulative changes in stock returns after bad news from the US economy

	ANDR	EBS	EVN	MMK	OMV	POST	RBI	SBO	TKA	VER	VIG	VOE	WIE
CCI	15	20	0	0	60	0	60	0	10	35	0	60	60
CPI	0	0	0	0	0	0	0	5	0	25	0	(10)	5
cCPI	0	0	0	0	5	0	5	0	0	5	0	(10)	5
DGO	(5)	5	0	0	5	5	0	0	45	0	5	(55)	20
EHS	5	(10)	(5)	0	20	10	5	0	15	0	0	20	0
HS	0	0	0	(55)	0	0	0	0	0	0	0	0	0
IP	0	0	0	(5)	10	(5)	(25)	0	0	0	10	60	5
ISM	60	60	0	0	25	0	35	10	50	5	10	20	20
IJC	25	55	0	(5)	0	0	5	(5)	10	5	15	20	0
LI	0	0	5	0	0	0	0	0	0	0	0	0	0
NHS	0	0	(5)	10	0	60	0	0	0	(5)	0	10	30
NFP	35	25	0	0	20	0	60	55	30	15	10	(55)	60
PI	0	0	(10)	0	0	0	0	(50)	0	5	(10)	0	0
PFBOS	(5)	0	0	(55)	0	0	0	0	0	0	0	0	0
PPI	0	0	0	0	0	0	0	0	5	0	0	0	5
cPPI	0	0	(5)	(5)	0	0	0	0	5	0	0	0	0
GDP	20	30	(15)	0	(10)	0	40	0	15	35	5	60	0
RS	(5)	10	0	0	0	(5)	5	20	5	(10)	20	60	5
cRS	(10)	10	0	(5)	5	10	5	15	0	25	10	60	5
All	60	60	(30)	5	60	10	60	40	45	35	40	60	60
All without IJC	60	60	0	0	60	5	60	35	45	35	55	60	60

Notes: This table presents the length (in minutes) of an uninterrupted period from news announcement with significant (at a level of at least 5% mean of CAR_t. When the mean of CAR_1 is insignificant then the period is measured from 5 minutes after news announcements. The length of this second period is presented in parentheses.

Table 11: Length of significant cumulative changes in stock returns after good news from the US economy

	ANDR	EBS	EVN	MMK	OMV	POST	RBI	SBO	TKA	VER	VIG	VOE	WIE
CCI	10	15	0	0	5	5	5	0	0	10	10	5	15
CPI	0	0	0	0	0	0	0	0	(55)	0	0	0	(55)
cCPI	0	0	0	(5)	0	0	0	(10)	(55)	0	0	35	10
DGO	0	15	15	0	0	0	0	0	0	0	10	0	0
EHS	10	15	0	(10)	0	15	5	(5)	0	0	5	15	10
HS	5	5	0	(25)	0	0	0	0	0	0	10	0	0
IP	0	15	(5)	10	0	0	(10)	0	(5)	(55)	(5)	15	0
ISM	60	40	(55)	45	55	0	40	30	15	20	40	60	50
IJC	15	60	(10)	(20)	30	0	35	(5)	0	60	0	30	20
LI	0	0	(35)	(55)	0	0	0	0	0	(5)	(15)	0	0
NHS	0	5	(20)	0	5	20	0	0	0	0	0	0	5
NFP	60	60	0	0	60	25	60	60	60	30	60	60	35
PI	0	0	0	40	0	0	0	0	0	0	(5)	0	5
PFBOS	0	5	0	5	(10)	0	5	0	0	0	0	10	0
PPI	0	0	(5)	(55)	0	(5)	5	60	5	5	0	0	(45)
cPPI	(10)	0	60	0	0	5	5	15	0	0	0	0	60
GDP	60	60	5	25	5	0	30	(5)	60	0	5	5	5
RS	20	60	(20)	(45)	(30)	(5)	45	0	0	0	60	15	5
cRS	15	60	(20)	(45)	30	(5)	40	0	0	5	(55)	35	25
All	60	60	(55)	60	60	50	50	25	15	60	35	60	60
All without IJC	60	60	(55)	50	60	45	50	25	55	60	55	60	60

Notes: This table presents the length (in minutes) of an uninterrupted period from news announcement with significant (at a level of at least 5% mean of CAR_t. When the mean of CAR_1 is insignificant then the period is measured from 5 minutes after news announcements. The length of this second period is presented in parentheses.

The strongest cumulative impact of good news is observed after NFP announcements where there are 8 cases of significant CAR_t in one-hour periods. From Table 6 we observe a delayed reaction of EVN and MMK returns to good news from the American economy. This fact is indicated by the large number of values in parentheses.

Impact of extreme news

Tables 12 and 13 report results of the event study analysis performed on the basis of announcements of very surprising news, i.e. announcements with $|S_{\text{ik}}| > 0.5$. The $\overline{ASR}_1$ values just after bad news presented in Table 12 are mainly smaller than the respective averages in Table 7. This means that restricting the analysis only to announcements with a large difference between the announced and expected value of the indicator leads to a stronger reaction of investors. Actually, only after announcements of PI do $\overline{ASR}_1$ values increase, but this is mainly due to the very specific impact of this indicator. As can be seen in Tables 7 and 8 announcements of PI are usually followed by positive values of the average $\overline{ASR}_1$ for both bad and good news.

For most of the indicators restricting the analysis reduces the number of significant averages of abnormal returns ASR_1. We suppose that (as in the case of EBS) this is caused by the changes in the sample length.

From the analysis of the impact of good news it is difficult to conclude whether the restriction weakens or strengthens changes in stock prices. In Table 13 the number of $\overline{ASR}_1$ values lower than in Table 8 is very close to the number of values greater than previously. However, when compared to the impact of bad news, in Table 13 we observe more cases when the restriction of the analysis reduces the number of significant means of abnormal returns (see for example CCI or EHS).

Analogously to the previous subsection we performed bootstrap tests to verify whether restricting the sample of announcements only to very bad or very good news leads to a significantly stronger reaction. For announcements of 9 indicators averages $\overline{ASR}_1$ for very bad news are significantly lower for at least one firm. However, only in the case of two indicators (NFP and cRS) can we state that reducing the sample of announcements gives significantly lower averages of ASR_1. Besides, there are no visible patterns or relationships among the results of the bootstrap tests. In addition, the analysis by companies lead to mixed results. The largest number of significant averages (4) is observed for the returns of four companies, namely ANDR, EBS, OMV, and VOE.

The results of bootstrap tests for very good news are clearer. From Table 13 we can conclude that limiting the analysis to the sample of very good news does not give significantly stronger changes in stock prices. For the majority of indicators the average $\overline{ASR}_1$ computed on the basis of the restricted sample does not differ from the averages computed after other announcements. The only exception are announcements of NFP for which we observe five cases of the significant impact of

Table 12: Average abnormal standardized returns in first five minutes after bad news from the US. Announcements with $|S_{\text{ik}}| > 0.5$

	ANDR	EBS	EVN	MMK	OMV	POST	RBI	SBO	TKA	VER	VIG	VOE	WIE
CCI (33)	-0.66*	-0.46***	0.03	0.02	-0.50**	0.17	-0.90***	0.22	-0.13	-0.18	-0.07	-0.42*	-0.59**
CPI (39)	-0.06	-0.17	0.04	0.15	-0.33	-0.10	-0.14	-0.33**	-0.17	-0.48***	-0.15	-0.33*	-0.63**
cCPI (41)	-0.17	-0.13	-0.03	0.06	-0.51**	-0.13	-0.35**	-0.37*	-0.05	-0.37**	-0.33	-0.32	-0.51**
DGO (43)	-0.25*	-0.70***	-0.01	0.00	-0.52*** [a]	-0.11	-0.34***	-0.14	-0.50***	-0.32***	-0.70***	-0.50** [a]	-0.46***
EHS (27)	-0.55**	-0.53** [a]	-0.05	-0.01	-0.66**	-0.05	-0.36**	0.16	-0.10	-0.23	-0.13	-0.70***	-0.11
HS (55)	-0.01	-0.34	0.07	-0.07	-0.06	-0.02	0.16	-0.08	0.10	-0.04	-0.20**	-0.03	-0.23
IP(63)	-0.27	-0.18	0.05	-0.06	-0.38***	-0.07	-0.29**	-0.14	0.00	-0.26*	-0.28**	-0.34***	-0.11*
ISM (23)	-1.24***	-1.54*** [a]	-0.07	-0.01	-1.43***	-0.53	-0.97***	-0.71***	-0.71***	-0.58***	-0.58**	-1.01***	-0.54
IJC (179)	-0.24***	-0.44***	0.01	-0.20	-0.20** [a]	-0.21***	-0.34*** [a]	-0.10**	-0.16***	-0.24***	-0.15***	-0.27***	-0.15*** [a]
LI (18)	-0.14	-0.50	0.42***	-0.05	-0.13	-0.37	-0.27	-0.16	-0.03	0.26	-0.20	-0.33	-0.55*
NHS (18)	-0.33 [a]	-0.50***	-0.31	-0.33	0.15	-0.03	-0.26	-0.20	0.21	-0.18	-0.29**	0.13	0.01
NFP (37)	-1.01*** [a]	-1.19***	-0.67 [a]	-0.20	-1.13*** [a]	-0.21	-1.25***	-0.81*** [a]	-0.71**	-1.04*** [a]	-0.73***	-1.36*** [a]	-1.22***
PI (28)	0.38***	0.37	-0.13	-0.11	0.33	0.21	0.42	0.47	0.34**	0.41	0.10	0.21	0.06
PFBOS (47)	-0.37** [a]	-0.23	-0.09	-0.05	-0.18	-0.05	-0.15	-0.20*	-0.14	0.00	-0.13	-0.21	-0.06
PPI (40)	-0.20	-0.29**	-0.02	-0.04	-0.32**	0.11	-0.19***	0.10	-0.12	-0.03	-0.12	-0.34** [a]	-0.06
cPPI (43)	-0.12	-0.28	-0.08	0.00	-0.19	0.07	-0.03	-0.06	-0.23**	-0.15	0.02	0.00	-0.28**
GDP (37)	-0.33**	-0.62***	-0.04	-0.12	-0.71*** [a]	-0.23	-0.68***	-0.50	-0.51***	-0.33**	-0.67***	-0.64***	-0.37***
RS (54)	-0.32**	-0.74***	-0.03	-0.10	-0.26***	-0.47	-0.55***	-0.57***	-0.03*	-0.19*	-0.64***	-0.67***	-0.42**
cRS (47)	-0.64*** [a]	-0.91*** [a]	0.06	-0.12	-0.43***	-0.54***	-0.76*** [a]	-0.60***	-0.35** [a]	-0.34***	-0.79*** [a]	-0.94*** [a]	-0.53**
All (631)	-0.32***	-0.41***	-0.01	-0.08	-0.33***	-0.11**	-0.36***	-0.17***	-0.16***	-0.23***	-0.27***	-0.38***	-0.29***
All without IJC (532)	-0.33***	-0.42***	-0.05	-0.05	-0.39***	-0.10*	-0.37***	-0.20***	-0.14***	-0.21***	-0.32***	-0.41***	-0.33***

Notes: *, **, *** – indicates significance of expected value of ASR_t at a level of 10%, 5%, and 1%, respectively. [a] – indicates significance of expected value of ASR_t value for a sample of very bad announcements at a 5% level.

Table 13: Average abnormal standardized returns in first five minutes after good news from the US. Announcements with $|S_{\text{ik}}| > 0.5$

	ANDR	EBS	EVN	MMK	OMV	POST	RBI	SBO	TKA	VER	VIG	VOE	WIE
CCI (42)	0.48***	0.28***	-0.11	-0.10	0.09	0.10	0.26**	0.10	-0.17	0.02	0.17*	0.02	0.43***
CPI (53)	-0.06	-0.27	0.01	-0.06	0.12	-0.20	0.06	-0.28	0.01	0.25*	-0.11*	-0.02	0.05
cCPI (60)	0.18	0.01	-0.04	-0.03	0.20	0.03	-0.01	0.03	0.19	0.11	-0.11	0.21**	0.17*** [a]
DGO (38)	0.15	0.17	0.31**	-0.02	-0.08	-0.12	0.06	-0.08	0.08	0.18	0.23**	0.39	0.34
EHS (27)	0.22	0.37	-0.01	0.31	0.30*	0.28**	0.19	-0.02	0.31*	-0.23	0.23**	0.62***	0.15
HS (39)	0.38**	0.42**	-0.05	-0.20	0.03	0.04	0.72*** [a]	-0.15	0.03	-0.05	0.10	0.19	0.24
IP (44)	0.11	0.34***	0.09	0.15***	0.20	0.21	0.14	0.31	0.20	0.30**	0.09	0.42***	0.24
ISM (36)	0.70*** [a]	0.67***	0.25**	0.10	0.67**	0.24**	1.00***	0.71***	0.41***	0.23	0.65***	0.80***	0.36***
IJC (178)	0.17**	0.36***	-0.02	-0.14	0.21***	0.03	0.24***	0.04	0.17 [a]	0.35***	0.12*	0.32***	0.22*
LI (36)	0.23*	0.12	0.38**	0.18	-0.18	0.16	0.16	0.10	0.17	-0.11	-0.08	0.13	-0.30
NHS (23)	0.18	0.25	0.01	-0.29	0.10	0.32***	-0.19	0.02	0.11	0.18	0.05	-0.02	0.43
NFP (25)	1.02***	2.32***	0.42*** [a]	-0.12	1.70*** [a]	0.36	1.61***	0.64***	1.15***	1.04*** [a]	1.40***	2.50*** [a]	1.45*** [a]
PI (28)	0.02	0.26	0.11	0.22***	-0.08	0.00	0.12	-0.10	-0.10	-0.04	0.01	0.03	0.25***
PFBOS (48)	0.01	0.34*	0.01	0.19*	0.23**	-0.06	0.28**	0.32* [a]	0.09	-0.08	-0.07	0.49***	0.19
PPI (44)	-0.20*	-0.03	-0.20*	-0.09	-0.07	-0.30	-0.18	-0.45*	-0.13*	-0.13	-0.03	-0.22*	-0.12**
cPPI (32)	-0.33	-0.12	-0.21**	0.14	-0.26**	-0.56***	-0.29**	-0.28*	-0.11	-0.24*	0.04	-0.26	-0.06
GDP (32)	0.41**	1.25***	-0.23	0.39***	0.35*	0.34***	0.93***	0.09*	0.56***	0.20	0.70***	0.52**	0.62*
RS (39)	0.36*	0.65***	0.21	0.21**	0.34*	-0.44***	0.64***	-0.15	-0.02	0.22**	0.41**	0.50***	0.41**
cRS (28)	0.50***	0.75***	0.29	0.37***	0.47**	-0.18**	0.76**	-0.05	0.15	0.40**	0.57*** [a]	0.71***	0.48**
All (621)	0.30***	0.46***	0.07***	0.04***	0.25***	0.07***	0.35***	0.09***	0.18***	0.21***	0.22***	0.40***	0.31***
All without IJC (520)	0.28***	0.46***	0.07*	0.08***	0.23***	0.06***	0.36***	0.09*	0.19***	0.14***	0.23***	0.42***	0.31***

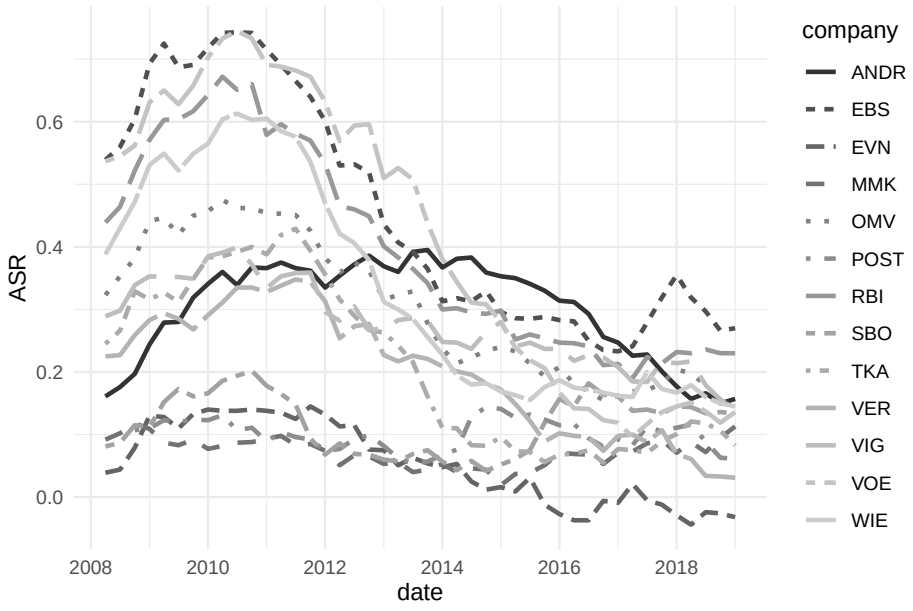
Notes: *, **, *** – indicates significance of expected value of ASR_t at a level of 10%, 5%, and 1%, respectively. [a] – indicates significance of expected value of ASR_t value for a sample of very good announcements at a 5% level.

the sample reduction. For four of them (EVN, OMV, VER, and VOE) the impact of very bad news (Table 12) was also stronger than other bad news.

Changes in reaction strength

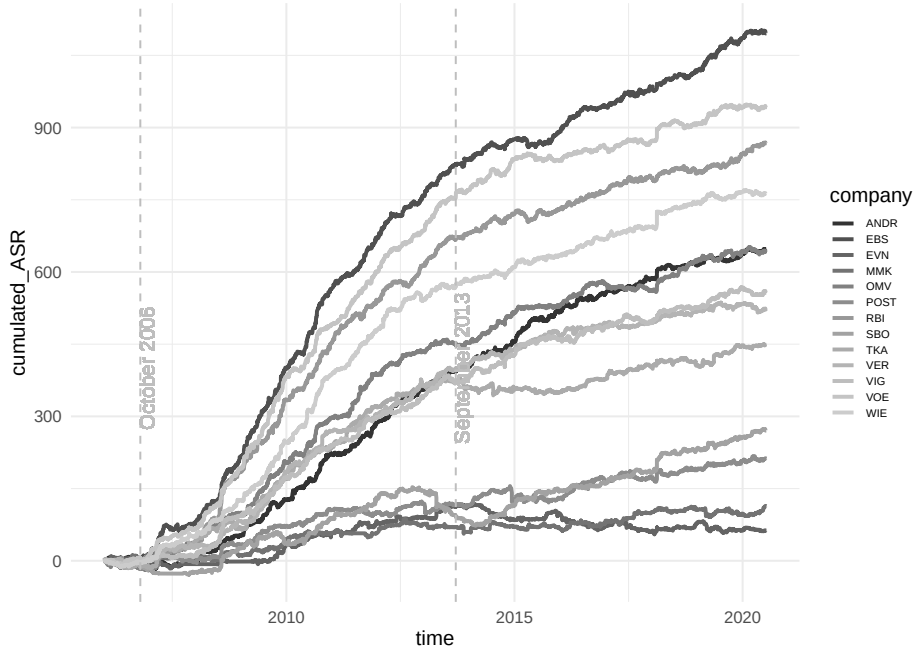
In order to analyze how the impact of US macroeconomic news announcements on stock prices on the VSE has changed over the last 15 years we performed an event study analysis in the subperiods. As described in the previous subsection we analyze the significance of the average of modified abnormal standardized returns $MASR_1$ in the first five minutes after news announcements. Values of the averages $\overline{MASR}_1$ in 4-year windows shifted every quarter are presented in Figure 10 for each company under consideration. All of them show a similar pattern to that observed for EBS in Figure 7.

Figure 10: Averages of modified abnormal standardized returns ($\overline{MASR}_1$) of ATX stocks in 4-year windows



Notes: Modified abnormal standardized returns $MASR_1$ are equal to ASR_1 after good news announcements and are equal to $-ASR_1$ after bad news announcements. Averages ($\overline{MASR}_1$) of abnormal standardized returns of EBS in the first five minutes after US macroeconomic news announcements were computed in 4-year windows. Windows were shifted every three months to cover the whole period 2006–2020. On the X axis we marked the centers of the windows.

Figure 11: Values of cumulated modified abnormal standardized returns $CMASR_t$ of ATX stocks



Notes: For a given time t between January 1, 2006 and June 31, 2020 the value of cumulated modified abnormal standardized returns $CMASR_t$ equals the sum of $MASR_1$ for all announcements of unexpected US macroeconomic news between January 1, 2006 and time t. Modified abnormal standardized returns $MASR_1$ are equal to ASR_1 after good news announcements and are equal to $-ASR_1$ after bad news announcements.

The highest values of the averages are observed in windows just after the global financial crisis that had started in the US. Then, in subsequent years, the power of changes in stock prices implied by unexpected news from the US economy decreased. Irrespective of these changes in magnitude, for most of the companies under consideration the impact of US news is significant in each subperiod. The only exceptions are EVN and MMK, where insignificant averages of $MASR_1$ dominate. The weakening of the impact of US macroeconomic news at the end of the period meant that OMV, POST, and VIG had insignificant averages in the last subperiod.
Another look at changes in the strength of reaction implied by US macroeconomic news follows from an analysis of Figure 11. As in Figure 9, here we present the values of cumulated modified abnormal standardized returns $CMASR_t$ computed for each company under consideration. As before, we can observe similar changes in their slopes. In the first period, before 2007, $CMASR_t$ graphs are horizontal. Then,

almost simultaneously, the slopes increase. Of course, the strength of these changes in the slopes varies from company to company and depends on a company's individual sensitivity to news from the US. However, in late 2012 or at the beginning of 2013 $CMASR_t$ slopes decrease for most stocks. This indicates a weakening in the strength of changes in stock prices just after unexpected news from the US economy.

5 Conclusions

In this paper we analyzed the impact of unexpected news from the US economy included in announcements of 19 indicators on the prices of the largest and the most liquid stocks listed on the Vienna Stock Exchange. To do this we applied an event study analysis to 5-minute returns of 13 stocks from January 2006 to the end of June 2020. Taking such a long period into account allowed us also to investigate the changes in the strength of investors' reactions to US macro news in last 15 years.
The main conclusion of this paper is that prices of the largest firms listed on the VSE are heterogeneous in their reaction to unexpected news from the US economy. The differences are observed in the number of significant changes in the first five minutes after news announcements, as well as in the strength of the reaction. The firms, which prices significantly react to the largest number of announcements are EBS, WIE, VOE, and RBI. Their shares are also among the most actively traded as indicated by very high average number of transactions per minute reported in Table 2. On the other hand, the least liquid companies in the sample (EVN, MMK, POST, and SBO) show the smallest number of significant changes in returns implied by US macroeconomic news announcements. Similarly to the significance of the reaction, relative strength of the changes in prices in first five minutes after news announcements is related to the intensity of trade. The highest absolute values of average abnormal standardized returns are observed in the case of EBS, RBI, and VOE, while the prices of EVN and MMK show the weakest reaction to news from the US. These relationships between liquidity and the way stock prices react to US macroeconomic news confirm that new information is faster incorporated into prices of more actively traded stocks. Less liquid stocks with very low number of transactions suffer more from the negative impact of microstructure effects, which slow down the process of incorporating new unexpected information into prices. This is confirmed by delayed reaction of EVN and MMK prices. Comparing the results for individual companies allows us to conclude that the main factor for the strength and significance of the reaction to US macroeconomic news announcements is the intensity of trade, not the sector in which a given company operates.
Analysis presented in the paper indicate that unexpected macroeconomic news from the US implies a strong and significant reaction of stock prices just after announcements. In the majority of cases significant changes in stock prices are visible mainly in the first five minutes after a news release. Later, the changes are in general insignificant and of smaller magnitude. However, the accumulation of these small

changes leads to significant changes in stock prices observed one hour after news announcements. This is in line with the results of Gurgul and Wójtowicz (2014, 2015) obtained for stock market indices. The results of the analysis presented in this paper show that in the case of the most liquid stocks from the Vienna Stock Exchange unexpected information is almost all included in prices in the first few minutes after its announcement and after that very short period it does not provide any additional advantage to investors.

A comparison of the impact of bad and good unexpected news shows that the latter implies more cases of significant changes in stock prices. Regardless of the notion of information, the largest number of stocks with significant changes in returns is implied by announcements of the ISM Manufacturing Index (ISM) and Nonfarm Payrolls (NFP).

The values of average abnormal returns indicate that unexpected good news from the US economy usually leads to stronger changes in stock prices than unexpected bad news. However, an additional analysis and comparison of the distribution of abnormal returns after both groups of announcements showed that the hypothesis about the symmetry in investors' reactions can only be rejected in a few cases. Hence, we can conclude that the impact of good and bad news on stock prices of the largest companies listed on the VSE is in general symmetrical.

An analysis in subperiods proves that the impact of unexpected news from the US was strongest during the global financial crisis 2007–2009. After that period the strength of changes in stock prices implied by the announcements decreased. However, for most companies under consideration the impact of US news is significant in each subperiod. The only exceptions are the least liquid stocks: EVN and MMK. A more detailed analysis of abnormal returns after each announcement revealed that an increased impact of macro news from the US was observed from the end of 2006 (when the first signs of the crisis were visible) until 2013 when stock markets recovered from the crisis and Fed decided to stop quantitative easing.

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