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ATX response to U.S. macroeconomic announcements

# The Response of Intraday ATX Returns to U.S. Macroeconomic News*

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*Abstract*
*Linkages between important news and asset price movements as a response to released information is one of the main issues in financial market theory and practice. The goal of this paper is to study the impact of U.S. macroeconomic data announcements on the prices of the most liquid shares quoted on the Vienna Stock Exchange. On the basis of intraday data, we verify the significance of changes implied by releases of ten important indicators describing the U.S. economy. Using nonparametric rank tests in the framework of event study methodology, we determine when investors on the VSE react to new information. This approach makes it possible to assess the strength, direction and duration of the impact of U.S. macroeconomic data announcements.*

## 1. Introduction

Numerous institutions around the world regularly make scheduled public announcements of macroeconomic data about employment, inflation, prices, production, consumption, etc. These macroeconomic announcements receive considerable attention in both the daily financial press and the academic literature. It is important which particular items of macroeconomic information are strongly reflected in price movement. Knowledge of the possible impact of scheduled macroeconomic news on equity prices is essential in the assessment of stock market efficiency and for the prediction of stock market reactions to released items of information.

The U.S. economy is the largest in the world and its impact on other economies in the world is obvious. Hence, most papers investigate the impact of U.S. macroeconomic news on various stock markets, both developed (e.g. Andersen *et al.,* 2003; Nikkinen and Sahlström, 2004; Nikkinen *et al.*, 2006) and emerging (e.g. Hanousek *et al.*, 2009; Gurgul and Wójtowicz, 2014). These research studies (described in detail in the next section) prove the very strong and significant impact of U.S. macroeconomic news announcements on a variety of stock markets.

In this paper we study the impact of several U.S. macroeconomic news announcements on the Vienna Stock Exchange.

The VSE is an example of a small developed stock market between large developed Western European stock markets and emerging markets in Central and Eastern Europe. Due to geographical and historical reasons, the Austrian economy is

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strongly related to the German economy. Similarly, the VSE is strongly related to the Frankfurt Stock Exchange. On the other hand, the VSE is the leader of the CEE Stock Exchange Group (CEESEG), the largest exchange group in Central and Eastern Europe. In the last decade, CEESEG has been confronted with its local rival in Central and Eastern Europe—the Warsaw Stock Exchange. The Vienna Stock Exchange is a kind of bridge between stock markets in the post-communist Eastern European economies and the large developed Western European stock markets. This means that the VSE has, to some extent, properties of both kinds of stock markets. Hence, it is valuable to analyze the reaction of the VSE (represented by the ATX index) to U.S. macroeconomic data in the light of reactions to macroeconomic news of both groups of stock markets and compare it with the results for both developed and emerging European stock markets. This is one of the ways in which this study contributes to the body of literature on the impact of macroeconomic news releases on stock markets. This paper also extends previous works by applying event study methodology to intraday data. To verify the significance of the impact of U.S. announcements of macroeconomic data on the ATX, we apply the nonparametric rank test proposed by Kolari and Pynnönen (2011), which is a generalization of the widely applied test of Corrado and Zivney (1992). The application of event study, instead of the commonly used regressions with dummy variables, allows us to examine the significance of the reaction of stock prices to macroeconomic news announcements and also the duration of the impact. In our contribution we apply intraday returns of the ATX from January 2007 to December 2013.[1] On the basis of this intraday data, we study not only the reaction of stock prices just after news announcements, but also stock price dynamics in the following hours until the end of the trading session. This allows us to examine whether unexpected U.S. macroeconomic news has a permanent effect on stock prices or whether this effect is only temporary. Because the period under study ranges from the beginning of 2007 to the end of 2013, we are able to study the reaction of the VSE to unexpected news from the U.S. economy during different phases of the business cycle, in particular during the financial crisis which broke out in 2008 and after it.

The remainder of the paper is organized as follows. In the next section we give an overview of the economic literature on the effects of macroeconomic announcements on stock markets. In Section 3 we present the data used in this study and give a brief description of the event study methodology applied. The empirical findings and discussion are presented in Section 4. The final section concludes the paper and provides some suggestions for future research.

## 2. Literature Review

It follows from economic theories that two important fundamentals are responsible for the level of stock prices: expected cash flows and discount rates. Both of these, in turn, depend on the risk-free discount rates and the risk premium (Campbell and Mei, 1993). Macroeconomic news may, therefore, have a significant impact on stock returns if it conveys new information on these factors. In the economic literature there is much evidence for the effect of monetary policy and inflation announcements on stock market performance (see e.g. Pearce and Roley,

[1] We would like to thank the Vienna Stock Exchange for supplying the tick-by-tick data.

1983; Hardouvelis, 1987; McQueen and Roley, 1993; Rigobon and Sack, 2002; Bernanke and Kuttner, 2005). However, the effects of other macroeconomic variables are often not clear. The probable reason for that is the problem in determining which effect dominates, the cash flow effect or the discount rate effect. First of all, if the released news on real economic activity is better than expected, the cash flows are likely to increase. This would imply a rise in stock prices. However, good news on real economic activity can cause an increase of discount rates. This might follow from a forecast by market participants that economic expansion would lead to higher inflation and that in consequence the target interest rates would rise (Edison, 1997). This, in turn, could push down stock prices. As we can see, the net effect on equity prices will depend on whether the cash flow effect or the discount rate effect is dominant. There can be dominance of one effect when stock price movements are compared with changes in bond prices. Bond and stock prices move in the same direction when announcements have a stronger impact on interest rate expectations than earnings expectations.

To see what kind of macroeconomic announcements impact financial markets, Fair (2002) examined the sources of large changes in the S&P 500 between 1982 and 1999. Many large one- to five-minute changes in S&P 500 futures do not correspond to any obvious events, though Fair found 69 changes that were connected with known events. Twenty-two of them were related to monetary macroeconomic announcements (money supply or interest rate), while 31 of them were due to nonmonetary macroeconomic announcements (unemployment, CPI, PPI, retail sales, etc.).

An effect of globalization is increasing linkages between markets around the world. Macroeconomic announcements about one economy may have a significant impact not only on the domestic market, but also on foreign markets. It is assumed that macroeconomic news can influence foreign markets through both real and financial cooperation and link channels between domestic and foreign markets. However, the evidence is not consistent (see, among others, Chen *et al.*, 1986; Fleming and Remolona, 1997; Ghosh *et al.*, 1999; Bollerslev *et al.*, 2000; Furfine, 2001; Balduzzi *et al.*, 2001; Kim and In, 2002; Green, 2004; Ehrmann and Fratzscher, 2004; Wongswan, 2006; Nikkinen *et al.*, 2006; Kim and Nguyen, 2008, 2009; Albuquerque and Vega, 2009).

International or even global effects may occur when macroeconomic news relates global factors. This is the case with the largest economies, which are most important for the global economy. Economists agree that U.S. macroeconomic variables do contain information about global factors. Thus, in the economic literature (see, for example, Nikkinen and Sahlström, 2004) there is a widespread view that only U.S. macroeconomic announcements have a significant impact on foreign stock markets. Early studies focused on the impact of U.S. macroeconomic news on the U.S. stock market (Geske and Roll, 1983; McQueen and Roley, 1993; Li and Engle, 1998). This stream of research was continued by Bomfim (2003) (the effect of macroeconomic news about monetary policy on the volatility of stock returns in the U.S.) and Boyd *et al.* (2005), who studied the impact of U.S. unemployment rate announcements on the S&P 500 index.

Subsequent analyses were extended to other developed stock markets. For example, Nikkinen and Sahlström (2004) examined the impact of U.S. and domestic

macroeconomic announcements on the German and Finnish equity markets. Their study indicates that the implied volatility on both markets reacts significantly only to U.S. announcements, particularly those about the unemployment rate and PPI. Additionally, CPI announcements have effects on the Finnish market. Nikkinen *et al.* (2006) checked the impact of U.S. macroeconomic news announcements on 35 stock markets in various parts of the world. The markets were divided into six groups including some developed and emerging markets in Europe, Asia and Latin America. Nikkinen *et al.* found that developed stock markets in Europe and Asia respond similarly to U.S. macroeconomic surprises. Announcements of CPI, employment costs, the employment situation and NAPM manufacturing imply an increase in the volatility of market indices of G7 countries. The last three indicators also significantly influence non-G7 European developed markets (including Austria). By contrast, the reaction of CEE economies in transition (including the Czech Republic, Hungary, Poland, Russia and Slovakia) to announcements of U.S. macroeconomic indicators is insignificant. This indicates an essential difference in the reaction to U.S. macroeconomic news between developed and emerging markets in Europe. However, there were also observed differences in reaction to U.S. announcements among European developed markets.

Singh *et al.* (2013) showed that U.S. macroeconomic surprises more frequently impact volatility than stock returns on developed markets. For example, volatility is influenced by U.S. news in the U.K., France, Germany and Italy, while returns are affected only in Germany.

Recently, intraday data have been frequently applied to the analysis of stock market reactions to U.S. macroeconomic announcements. Andersen *et al.* (2007) checked, on the basis of five-minute returns, how U.S., German and British stock, bond and foreign exchange markets responded to U.S. macroeconomic news. They established that news induced conditional mean jumps. However, the markets differ in their reactions to news and their responses depend on the stage of the business cycle. The impact of scheduled U.S. macroeconomic announcements on equity returns in four major European developed stock markets, i.e. British, French, German and Swiss, was investigated by Harju and Hussain (2011). Using high-frequency data, they found that all markets under study react similarly to U.S. macroeconomic news announcements. News about CPI, PPI, retail sales, durable goods orders, the unemployment rate and industrial production induce an immediate and significant reaction of the intraday volatility and five-minute returns of CAC40, DAX30, FTSE100 and SMI.

The reaction of the Frankfurt Stock Exchange was also examined by Dimpfl (2011), who applied DAX one-minute returns from July 2003 to December 2006. He proved that investors on the FSE react just after a news release and the significant reaction takes place in the first ten minutes. Quite different results were obtained by Albuquerque and Vega (2009), who showed, among other things, a delayed response of the Portuguese stock market to U.S. data announcements. The PSI-20 index reacts significantly from 40 minutes to one hour and 20 minutes after a news release.

The reaction of emerging markets in Central and Eastern Europe to U.S. news announcements was examined by Hanousek *et al.* (2009), who analyzed how stock prices in the Czech Republic, Hungary and Poland respond to U.S. and eurozone

macroeconomic news. On the basis of five-minute returns, Hanousek *et al.* showed that the strongest reaction to all kinds of U.S. data announcements is observed on the Czech stock market, while investors on the Hungarian stock market react significantly only to negative news from the U.S. economy. The Warsaw Stock Exchange shows no reaction to any kind of U.S. macroeconomic news announcements.

Opposite conclusions follow from Gurgul and Wójtowicz (2014), who examined the reaction of the Polish stock market to U.S. announcements. On the basis of intraday data, they showed that the WIG20 (the main index of the Warsaw Stock Exchange) reacts to unexpected news from the U.S. economy in the first minute after a news release. A significant reaction is induced by announcements about industrial production, durable goods orders, retail sales and nonfarm payrolls, whereas announcements about nonfarm payrolls induce the strongest reaction.

## 3. Data and Methodology

### 3.1 Announcements

Each month there are a huge number of announcements coming from the U.S. economy. Various indicators are published almost every day. However, not all of them are relevant to this study. We chose announcements satisfying five conditions:

1. They are seen in the literature as important to investors.
2. They are released on a monthly basis and contain actual information about the U.S. economy.
3. They are released during trading sessions on European stock markets.
4. Their forecasts are published prior to release.
5. If possible, they do not coincide with announcements of other important macroeconomic indicators.

For example, from the second condition it follows that we do not consider Construction Spending because it is based on data for two months prior to the release month. Continuous trading on the Vienna Stock Exchange ends at 17:30 CET[2], so the third condition implies that the indicators under study should be released before 11:00 EST.

Finally, we chose ten macroeconomic indicators that describe the U.S. economy and are suitable for this study: the Consumer Price Index (CPI), the Producer Price Index (PPI), Industrial Production (IP), Retail Sales (RS), Durable Goods Orders (DGO), Nonfarm Payrolls (NFP), Existing Home Sales (EHS), Housing Starts (HS), New Home Sales (NHS) and Consumer Confidence (CC).

It should be noted here that as a measure of the labor market in the U.S. we chose Nonfarm Payrolls instead of the frequently used Unemployment Rate. We did this because, as follows from the literature (Andersen *et al.*, 2007), NFP is one of the most informative macroeconomic indicators.

The majority of the announcements under study (CPI, PPI, IP, RS, DGO, NFP and HS) are released at 8:30 EST (14:30 CET). CC, EHS and NHS are released at 10:00 EST (16:00 CET). Only IP is released at 9:15 EST (15:15 CET). Due to

[2] CET—Central European Time, EST—Eastern Standard Time.

the differences in the introduction of the Daylight Saving Time in U.S. and in Europe in March and October, some announcements reach the VSE one hour earlier, i.e. at 13:30 CET, 14:15 CET and 16:00 CET, respectively.

To describe the unexpected news contained in these macroeconomic indicator announcements, we compare the announced value of each indicator with its forecast. All these comparisons are based on the consensus published by Bloomberg a few days before the indicator announcements. This allows us to assign each release to one of three clusters: "above consensus", "below consensus" and "in line with consensus". Our analysis includes only announcements from the first two clusters because they contain unexpected news. An announcement of CPI and PPI higher than consensus is expected to have a negative impact, whereas announcements of the other indicators above consensus are expected to have a positive impact on the stock market. Analogously, CPI and a PPI lower than forecast are expected to have a positive impact and the other indicators below consensus are expected to be bad news for investors.

Since new information about the U.S. economy reaches investors around the world every day, it can happen that when announcements about some indicators are released, the consensus value published by Bloomberg a few days earlier is out of date. This fact biases our analysis, but it is impossible to eliminate it. However, to deal with the problem of the bias of market forecasts of indicator values, we take into account the sequence in which announcements about each indicator are released during the month. The indicator released first in the month is NFP. It is one of the indicators published by the Bureau of Labor Statistics in the Employment Report, which is released at the beginning of the month, usually on the first Friday. The CPI, PPI, IP and RS are published in the middle of the month. HS is usually released in the third week of the month. EHS and DGO are announced around the 26$^{th}$ of the month. CC, PI, NHS are usually released in the last week of the month. Since U.S. macroeconomic data are released by different U.S. offices on different days of the month, there are days when more than one of the announcements is released. This is frequently observed in the second half of the month, when the majority of the indicators are announced. When two or more indicators are announced on the same day, we accept only the first of them as an event. Usually it is an announcement released at 8:30 EST. Subsequent announcements on the same day are excluded from the sample because earlier news has an effect on expectations about the value of an indicator released later. When two or more announcements are published at the same hour (usually at 8:30 EST), we take them into account only if they do not contain contradictory information, i.e. when all of them are positive or all of them are negative or some of them are in line with the consensus. This allows us to avoid, or at least to minimize, the problem of confounding events that could bias the results of the event study. The final numbers of different types of announcements of each indicator taken into account are reported in *Tables 1–5* along with the results of the event study analysis.

The sequence in which U.S. macroeconomic indicator announcements are released plays important role also in how they are perceived by investors. NFP is the first to be published in the month. It describes the condition of the U.S. labor market in the previous month. This makes it very attractive to investors. The other

indicators, released later in the month, seem to attract less attention because they are usually announced one by one. The broad information flow in the middle of the month also has an impact on the quality of consensus values published by information agencies. For example, market forecasts are published by Bloomberg a few days before an announcement, usually at the beginning of the week, and any news after that changes investors' expectations and renders them out-of-date. Thus, for some announcements the difference between the released value of an indicator and its consensus may be the expected news. This bias should be taken into account when analyzing the results of our study.

### 3.2 Returns

The analysis of the impact of U.S. data announcements on the Vienna Stock Exchange presented in this paper is based on intraday prices of the ATX from 2 January 2007 to 31 December 2013. The ATX index describes the behavior of a portfolio of the twenty largest and most liquid companies quoted on the VSE.

In the literature about intraday data, five-minute stock returns are commonly applied to balance the accuracy of analysis and the negative effects of the market microstructure (Andersen *et al.*, 2003; Jones *et al.*, 2005; Hansen and Lunde, 2006; Andersen *et al.* 2007). However, the high liquidity of blue chips ensures that new information is expected to be reflected in the ATX as soon as it reaches the market, so the market microstructure may be assumed to have little impact on ATX returns. Hence, to describe the speed of the reaction of investors on the VSE, we employ one-minute log-returns of the ATX. Another reason for the use of one-minute returns is the fact that the empirical literature suggests that the reaction of a stock market to important news announcements occurs in the first five minutes (or even sooner) after announcements (Andersen *et al.* 2007; Harju and Hussain, 2011; Entorf and Steiner, 2007).

### 3.3 Event Study

The usual approach to assessing the impact of news announcements on intraday stock data is based on regression with dummy variables (e.g. Flannery and Protopadakis, 2002; Jones *et al.*, 2005; Andersen *et al.*, 2007; Harju and Hussain, 2011). This approach has serious shortcomings due to intraday volatility patterns and to the issue of overnight returns.

To avoid these problems, we apply an event study approach to the analysis of the impact of U.S. macroeconomic data announcements on the main index of the VSE. Previously, event study analysis has been widely applied to the analysis of the impact of news announcements on daily data (e.g. Corrado and Troug, 2008). However, in the more recent contributions referred to in the previous subsection, this approach was also applied to intraday returns (see Dimpfl, 2011; Gurgul and Wójtowicz, 2014).

In this paper, the events are all the unexpected macroeconomic news announcements described in Subsection 3.1 assigned to various clusters. To test the significance of abnormal returns around the events, we define a pre-event window with the length of 80 minutes and an event window with the length of 11 minutes. The event window consists of six one-minute returns before a news release and five

returns after it. More precisely, if we denote the event time (the moment of a news release) by $t = 0$, then the event window includes $t = -5,\ldots,5$, while $t = -85,\ldots,-6$ constitute the pre-event (or estimation) window. It should be noted here that the impact of the *i*-th news announcement can be observed only for $t \geq 1$. When $i$-th news is released at 14:30 CET, then $R_{i1}$ (return for $t = 1$) computed at 14:31 CET describes the change in stock prices from 14:30 to 14:31 CET.

The earliest announcements considered in this paper are released at 8:30 EST and they reach the VSE no earlier than 13:30 CET. This means that the earliest return employed in this study occurs at 12:14 CET. This is ten minutes after the intraday auction that takes place on the VSE from 12:00 to 12:04 CET. This also means that the pre-event window does not overleap the period of possible increased volatility at the beginning of the second part of continuous trading on the VSE. Similarly, the event period ends more than one hour before the end of continuous trading. This means that the data taken into account in our analysis are from the period of homogeneous volatility, so computations are not influenced by highly volatile returns at the beginning and at the end of the second part of a trading session. Moreover, because for each announcement we use only 91 one-minute returns (i.e. about one hour and a half) from the middle of a trading session, it is not necessary to take into account the intraday seasonality of return volatility.

Abnormal returns are defined as the difference between actual returns and their expected values, i.e. for the *i*-th event and time *t* they are given by the formula:

$$AR_{it} = R_{it} - E\left(R_{it}|\Omega_{t_0}\right) \tag{1}$$

where $E\left(R_{it}|\Omega_{t_0}\right)$ is the expectation of $R_{it}$ conditional on information set $\Omega_{t_0}$ for time $t_0$ at the end of the pre-event window. In this study we compute abnormal returns from the constant mean model where conditional expected returns are equal to the mean of returns in the pre-event window. It is a very simple model, but for these data we cannot apply a more complex model, such as a market model.

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 advantage of this nonparametric test is that it does not need any assumption about the normality of abnormal returns and it has relatively higher power than the other tests commonly used in event studies. It also allows testing of the significance of abnormal returns and cumulative abnormal returns in the event window. The test statistic is constructed as follows.

For each $i$-th event in the cluster we compute the average of returns in the pre-event window, and for $t = -86,\ldots,5$, the abnormal return $AR_{it}$ is defined as the difference between the actual return $R_{it}$ and the expected return approximated by the average from the pre-event window. Then, for each event, all abnormal returns in the event and pre-event windows are standardized:

$$SAR_{it} = AR_{it} / S_{AR_i} \tag{2}$$

where $S_{AR_i}$ is the standard deviation of abnormal returns in the pre-event window.

In order to account for any event-induced increase in volatility observed in the event window (Corrado, 2011; Corrado and Truong, 2008; Kolari and Pynnönen, 2011) we re-standardize the $SAR_{it}$ after a news release by dividing them by the cross-sectional standard deviation:

$$SAR'_{it} = \begin{cases} SAR_{it} & t = -86,\ldots,0 \\ SAR_{it} / S_{SAR_t} & t = 1,\ldots,5 \end{cases} \tag{3}$$

where

$$S_{SAR_t} = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}\left(SAR_{it} - \overline{SAR}_{it}\right)^2} \tag{4}$$

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 for given time $t_0$ are zero mean and unit variance random variables.

To study the impact of a news release, we test the significance of abnormal returns for each $t_0$ in the event window separately. Thus for each $t_0 = -5,\ldots,5$ the demeaned standardized abnormal ranks of $SAR'_{it}$ are given by the formula:

$$U_{it} = \frac{rank\left(SAR'_{it}\right)}{T+1} - 1/2 \tag{5}$$

for $i = 1,\ldots,N$, where $t \in \Theta = \{-86,\ldots,-6,t_0\}$, $T-1$ is the length of the pre-event window and $rank\left(SAR'_{it}\right)$ denotes the rank of $SAR'_{it}$ within the vector consisting of standardized abnormal returns from the pre-event window and $SAR'_{it_0}$. Hence, $U_{it_0}$ denotes the demeaned standardized abnormal rank of $SAR'_{it_0}$ and the null hypothesis of no news effect.

$$E\left(SAR'_{it_0}\right) = 0 \tag{6}$$

is equivalent to

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

To test this hypothesis, we apply the generalized rank $t_{grank}$ test statistic of Kolari-Pynnönen (2011) defined as:

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

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

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

In order to verify the cumulative impact of news announcements, we test the significance of cumulative abnormal returns for $t_0 = 1$ instead of abnormal returns themselves. For a given period $\tau$ the cumulative abnormal return at $t_0 = 1$ is defined as

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

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

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

where $S_{CARi\tau} = \sqrt{\tau} S_{ARi}$.

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 $SCAR_{i\tau}$. Finally, to compare abnormal returns in the pre-event window and cumulative abnormal return over the $\tau$-minute horizon, we define generalized abnormal returns as

$$GSAR_{it} = \begin{cases} SAR_{it} & t = -86, \ldots, 0 \\ SCAR'_{i\tau} & t = 1 \end{cases} \tag{12}$$

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

## 4. Empirical Results

### 4.1 Reaction of Volatility

As mentioned in Sections 2 and 3.3, announcements of important information may imply an increase in return volatility. To describe the impact of U.S. macroeconomic news announcements on ATX return volatility, we apply the event study methodology and Kolari-Pynnönen test to squared one-minute returns of the ATX. This means that in the procedure described in the previous section we simply replace returns with their squares. Since, we are interested in the impact of each macroeconomic indicator under study on ATX volatility, we perform tests separately in clusters containing all of the announcements of a given indicator that are in our dataset. We take into account all announcements of a given indicator irrespective of their relation to consensus. Each column of *Table 1* contains values of $\tau_{grank}$ statistics computed for each macroeconomic indicator in subsequent time points of the event window. In the header we also report the number of events in each cluster under

**Table 1 Reaction of the ATX Volatility to U.S. Macroeconomic News Announcements**

| | CPI (66 ev.) | PPI (63 ev.) | IP (25 ev.) | DGO (80 ev.) | HS (73 ev.) | EHS (75 ev.) | NHS (37 ev.) | CC (67 ev.) | RS (54 ev.) | NFP (81 ev.) |
|---|---|---|---|---|---|---|---|---|---|---|
| -5 | -0.17 | 1.12 | -0.23 | 0.28 | 0.74 | 0.45 | 1.17 | 1.97 | -0.55 | 2.07 |
| -4 | 1.76 | 0.65 | -0.12 | 1.42 | 2.32 | 0.97 | 0.28 | 0.02 | 0.10 | 0.99 |
| -3 | 1.50 | 1.14 | 0.42 | 1.94 | 0.70 | 0.59 | 0.65 | 1.21 | 0.29 | **3.24** |
| -2 | 1.02 | 0.57 | 0.79 | 1.05 | 1.22 | 0.07 | 1.49 | 0.73 | -0.51 | 1.61 |
| -1 | 0.77 | 0.15 | -0.53 | -0.70 | -0.77 | 1.13 | 1.36 | 0.28 | 1.35 | 2.39 |
| **0** | 1.97 | 0.10 | 0.92 | **3.01** | 0.38 | 2.30 | 1.44 | 1.85 | 0.13 | **3.07** |
| 1 | **7.81** | **7.91** | 1.04 | **9.43** | **8.09** | **7.38** | **5.21** | **7.74** | **7.72** | **10.23** |
| 2 | **7.46** | **7.36** | **2.58** | **8.38** | **7.41** | **6.66** | **4.48** | **7.68** | **7.02** | **9.32** |
| 3 | **7.75** | **7.12** | **-2.98** | **7.89** | **6.53** | **6.55** | **4.75** | **6.62** | **7.20** | **9.20** |
| 4 | **7.37** | **7.51** | **-2.50** | **7.33** | **7.38** | **6.66** | **5.00** | **6.71** | **6.48** | **9.72** |
| 5 | **6.75** | **7.25** | **3.51** | **7.69** | **6.99** | **6.34** | **3.03** | **6.57** | **4.68** | **9.11** |

*Notes*: ev. = events.

This table presents the values of Kolari-Pynnönen $\tau_{grank}$ statistics in tests of significance of the impact of announcements of U.S. macroeconomic indicators on ATX squared one-minute returns. $\tau_{grank}$ has asymptotic *t*-Student distribution with 79 degrees of freedom. Critical values are equal to 1.99 and 2.64 for the 5% and 1% significance levels, respectively. Statistics with absolute value greater than 1% critical values are in bold. Announcements of the following indicators are examined: the Consumer Price Index (CPI), the Producer Price Index (PPI), Industrial Production (IP), Retail Sales (RS), Durable Goods Orders (DGO), Nonfarm Payrolls (NFP), Existing Home Sales (EHS), Housing Starts (HS), New Home Sales (NHS) and Consumer Confidence (CC).

study. For the majority of indicators under study, a significant reaction of squared returns is observed from the first minute after a news announcement. It is worth noting that in the first minute return volatility increases dramatically, as evidenced by $\tau_{grank}$ statistics even greater than 10. When DGO and NFP are announced, volatility increases (not so dramatically) even just before a news release. The only exception to this pattern is IP, where volatility reacts after one minute from the announcements. Moreover, this slight increase is followed by volatility declines.

The results presented in *Table 1* confirm the very strong impact of U.S. macroeconomic news announcements on ATX volatility. This is in line with previous observations in the literature (cf. Harju and Hussain, 2011). It also confirms the presence of an event-induced increase in volatility and the necessity of re-standardization of the $SAR_{it}$ by formula (3).

### 4.2 Reaction of Returns

We study the reaction of the Vienna Stock Exchange to announcements of each single macroeconomic indicator describing the U.S. economy. According to the clustering outlined in the previous sections, we separately analyze the reaction of the ATX to announcements below and above consensus. The results of this analysis are summarized in *Tables 2* and *3*, where the means of ATX abnormal returns around the event time are presented. We also show the significance of the means indicated by the nonparametric Kolari-Pynnönen test. In the header, for each indicator, we report the number of events in the cluster.

**Table 2 Reaction of the ATX to U.S. Macroeconomic News Announcements below Consensus**

| | CPI (23 ev.) | PPI (25 ev.) | IP (17 ev.) | DGO (38 ev.) | HS (36 ev.) | EHS (43 ev.) | NHS (22 ev.) | CC (37 ev.) | RS (26 ev.) | NFP (42 ev.) |
|---|---|---|---|---|---|---|---|---|---|---|
| -5 | 0.0019 | 0.0065 | 0.0215 | 0.0074 | 0.0025 | -0.0033 | 0.0122 | -0.0014 | 0.0045 | 0.0067 |
| -4 | 0.0000 | 0.0011 | 0.0082 | 0.0084 | -0.0030 | -0.0081 | 0.0038 | 0.0060 | -0.0076 | 0.0010 |
| -3 | 0.0018 | **-0.0110**** | -0.0040 | 0.0076 | 0.0061 | -0.0030 | -0.0037 | 0.0138* | -0.0059 | -0.0050 |
| -2 | **-0.0110*** | 0.0073 | -0.0115 | -0.0003 | -0.0001 | 0.0012 | 0.0078 | -0.0093 | -0.0064 | 0.0069 |
| -1 | -0.0109 | 0.0013 | 0.0002 | 0.0004 | -0.0040 | -0.0030 | -0.0150 | 0.0076 | 0.0063 | 0.0138 |
| **0** | 0.0102 | 0.0018 | -0.0027 | -0.0036 | -0.0035 | -0.0134 | -0.0005 | -0.0016 | -0.0080 | 0.0086 |
| 1 | 0.0112 | 0.0165 | **-0.0184*** | **-0.0386**** | **-0.0297**** | **-0.0252**** | -0.0174 | **-0.0597**** | -0.0314 | -0.0874** |
| 2 | 0.0186 | 0.0112 | 0.0070 | -0.0287* | -0.0119 | -0.0201 | -0.0162* | -0.0499** | -0.0155 | -0.0542** |
| 3 | -0.0003 | 0.0009 | 0.0035 | -0.0049 | -0.0066 | -0.0177* | -0.0044 | -0.0276* | 0.0000 | -0.0056 |
| 4 | -0.0062 | 0.0052 | 0.0109 | -0.0005 | -0.0051 | -0.0186 | -0.0306* | -0.0250 | -0.0142 | -0.0151 |
| 5 | -0.0079 | -0.0131* | -0.0106 | 0.0040 | 0.0029 | -0.0054 | -0.0024 | -0.0074 | -0.0058 | -0.0035 |

*Notes*: ev. = events

*, ** = significance at 5% and 1%, respectively

This table presents means of abnormal one-minute returns of the ATX implied by announcements of the following indicators below consensus: the Consumer Price Index (CPI), the Producer Price Index (PPI), Industrial Production (IP), Retail Sales (RS), Durable Goods Orders (DGO), Nonfarm Payrolls (NFP), Existing Home Sales (EHS), Housing Starts (HS), New Home Sales (NHS) and Consumer Confidence (CC).

**Table 3 Reaction of the ATX to U.S. Macroeconomic News Announcements above Consensus**

| | CPI (22 ev.) | PPI (35 ev.) | IP (6 ev.) | DGO (40 ev.) | HS (37 ev.) | EHS (31 ev.) | NHS (15 ev.) | CC (29 ev.) | RS (27 ev.) | NFP (38 ev.) |
|---|---|---|---|---|---|---|---|---|---|---|
| -5 | -0.0085 | 0.0067 | 0.0198 | -0.0004 | 0.0043 | -0.0002 | 0.0011 | -0.0020 | -0.0073* | 0.0026 |
| -4 | 0.0160* | -0.0012 | -0.0024 | 0.0005 | -0.0020 | -0.0021 | 0.0257 | -0.0074 | -0.0060 | -0.0007 |
| -3 | 0.0088 | 0.0003 | 0.0126 | -0.0001 | 0.0001 | -0.0007 | -0.0108 | -0.0010 | -0.0018 | -0.0102* |
| -2 | 0.0022 | 0.0009 | -0.0168 | -0.0050 | -0.0074 | -0.0019 | -0.0172 | -0.0211 | 0.0013 | 0.0102* |
| -1 | 0.0034 | -0.0062 | 0.0020 | 0.0008 | -0.0039 | -0.0069 | 0.0185 | -0.0011 | 0.0009 | 0.0100 |
| **0** | 0.0001 | -0.0157* | -0.0157 | 0.0063 | -0.0003 | -0.0036 | -0.0266 | 0.0162 | -0.0026 | -0.0034 |
| 1 | -0.0412 | -0.0147 | 0.0093 | 0.0369** | 0.0240* | 0.0405** | 0.0511** | 0.0878** | 0.0418** | 0.0772** |
| 2 | -0.0205 | -0.0205 | 0.0378** | 0.0076* | 0.0133* | 0.0282** | -0.0004 | 0.0174 | 0.0065 | 0.0410* |
| 3 | -0.0077 | -0.0062 | 0.0354* | 0.0079* | 0.0061 | 0.0061 | 0.0208 | 0.0161 | 0.0071 | 0.0226 |
| 4 | 0.0209 | -0.0122 | 0.0028 | 0.0044 | 0.0144 | 0.0244 | -0.0107 | 0.0034 | 0.0078 | 0.0083 |
| 5 | -0.0108 | -0.0118* | -0.0021 | 0.0042 | -0.0030 | -0.0132 | -0.0014 | 0.0226** | 0.0130** | 0.0191* |

*Notes*: ev. = events

*, ** = significance at 5% and 1%, respectively

This table presents means of abnormal one-minute returns of the ATX implied by announcements of the following indicators above consensus: the Consumer Price Index (CPI), the Producer Price Index (PPI), Industrial Production (IP), Retail Sales (RS), Durable Goods Orders (DGO), Nonfarm Payrolls (NFP), Existing Home Sales (EHS), Housing Starts (HS), New Home Sales (NHS) and Consumer Confidence (CC).

The number of events in each cluster of announcements below consensus varies from 17 (for IP) to 42 (for NFP). The positive means of abnormal returns in the first minutes after inflation announcements below consensus (both CPI and PPI) confirm that this kind of announcement is seen by investors on the VSE as good news. Other announcements below consensus are seen as bad news and lead to a fall in stock prices on the VSE. These negative changes are significant in the first minute after the event when IP, DGO, HS, EHS, CC and NFP are announced. Additionally, after NFP and DGO announcements, the means of $AR_{it}$ s are significant in the first two minutes after the news release. When CC is announced below consensus, significant changes in the ATX are visible even in the first three minutes. The Kolari-Pynnönen test does not confirm any significant impact of unexpected positive news contained in CPI and PPI announcements. Similarly, no means of abnormal returns after RS announcements is significant.

In general, there is a "*calm before the storm"* effect—only a few $\overline{AR}_t$ s before the events are significant at least at the 5% level: $\overline{AR}_{-2}$ for CPI, $\overline{AR}_{-3}$ for PPI and CC announcements. This means that investors wait with their decisions until U.S. macroeconomic news is announced and then react immediately in the first minute.

When we compare the reaction of the ATX to the announcements of each indicator separately, it is clear that the reaction to NPF announcements is the strongest. In the first minute after the Employment Report is released, the ATX decreases by about –0.09% when NFP is smaller than forecast. This significant drop also continues in the next minute. This change in the ATX is also the largest among other $\overline{AR}_t$ s. In general, the strongest changes in the ATX are observed in just the first two minutes after announcements of bad news.

To compare the strength of the significant reaction of the ATX to negative information about IP, DGO, HS, EHS, CC and NFP, we apply the Kruskal-Wallis test. This test rejects the null hypothesis of the equality of the distributions of $AR_{i1}$ induced by these six indicator announcements ( $KW = 16.5$ with $p$-value $= 0.0056$ ). The values of $\overline{AR}_1$ indicate that a possible reason for this difference is the distribution of abnormal returns after NFP below consensus. Indeed, the Kruskal-Wallis test does not reject the null hypothesis when the distributions of $AR_{i1}$ after IP, DGO, HS, EHS and CC news releases are compared ( $KW = 7.2$ with $p$-value $= 0.126$ ). This indicates that the reaction of investors to the Employment Report differs from the reaction to the others indicators. Significant reactions to the other indicators appear similar to each other.

Taking into account the small number of IP announcements above consensus in the period under study, the results presented in the fourth column of *Table 3* may be heavily biased. As conjectured in the previous sections, announcements of CPI and PPI above consensus are bad news and imply negative abnormal returns. On the other hand, the remaining announcements above consensus are seen as good news and are followed by positive means of abnormal returns. All these positive reactions are significant in the first minutes after news announcements. Positive means of abnormal returns are significant in the first minute after all announcements except for the mean after IP announcements. The majority of them are significant at the 1%

level. Significant means of abnormal returns in the first minute after a news release vary from 0.024% after HS to 0.0878% after CC announcements. The Kruskal-Wallis test, however, does not indicate significant differences between the distributions of $AR_{i1}$ following announcements of DGO, HS, EHS, NHS, CC, RS and NFP. Therefore, we may conclude that investors on the VSE react similarly to this positive news. The abnormal returns implied by DGO, HS, EHS, CC, RS and NFP announcements also have significant means later in the event window. This indicates that U.S. macroeconomic news announcements above consensus cause abnormal changes in the ATX not only immediately after a news release, but also later (a kind of persistency can be observed). It is important that for each indicator these significant means are positive, which additionally confirms the positive impact of announced news. The strongest reaction is observed just after CC announcements ( $\overline{AR}_1 \cong 0.088\%$). As in *Table 2*, we can see a lack of significant changes in abnormal returns before a news release. The only important exceptions are NFP announcements, which are preceded by significant changes in abnormal returns for $t = -3$ and $t = -2$. However, $\overline{AR}_{-3}$ and $\overline{AR}_{-2}$ have different signs and therefore we do not suspect information leakage. We can attribute these changes to a nervous wait for the release of the Employment Report.

The above results allow us to classify all unexpected news into two clusters: "bad news" and "good news". The first cluster contains the announcements of CPI and PPI above consensus and the announcements of the other indicators below consensus. The "good news" cluster consists of the CPI and PPI announcements below consensus and the announcements of the other indicators above consensus. The Kruskal-Wallis test indicates a significant difference between the distributions of abnormal returns in the first minute after bad-news announcements implied by each indicator ( $KW = 22.7$ with $p$-value $\cong 0.0069$ ). Similarly, the reaction to good news significantly depends on the announced indicator ( $KW \cong 19.0$ with $p$-value $\cong 0.0249$ ).

The differences between the absolute values of $\overline{AR}_1$ s implied by the announcements of each indicator below or above consensus leads to the issue of the possible asymmetry of investor reaction on the VSE. To prove this, for each indicator we compare the distribution of $AR_{i1}$ after a good-news release with the distribution of $-\overline{AR}_1$ after bad-news announcements. For each indicator the Kruskal-Wallis test does not reject the null hypothesis of the equality of these distributions even at the 10% level. Hence, we can conclude that investors on the VSE react similarly to bad and good news conveyed by U.S. macroeconomic indicators.

In addition to the above analysis of each indicator separately, we study the joint impact of all good and all bad news from the U.S. economy on ATX intraday returns. We perform an event study in the two clusters of "good news" and "bad news". The results of this analysis are summarized in *Table 4*.

The values of mean abnormal returns reported in the second and fifth columns of *Table 4* indicate that investors' reactions are in line with the content of the announcement. Bad news implies abnormal returns with negative means, while good news is followed by positive mean abnormal returns in the first minutes after announcements. The nonparametric rank tests of Kolari and Pynnönen also indicate that the reaction

**Table 4 Reaction of the ATX to Announcements of Good and Bad U.S. Macroeconomic News in the Whole Period**

| | Bad news (303 events) | | | Good news (259 events) | | |
|---|---|---|---|---|---|---|
| *t* | $\bar{AR}_t$ (%) | $\tau_{grank}$ | *p*-value | $\bar{AR}_t$ (%) | $\tau_{grank}$ | *p*-value |
| -5 | 0.0039 | 1.099 | 0.2717 | 0.0003 | -0.179 | 0.8583 |
| -4 | 0.0018 | 0.234 | 0.8146 | -0.0002 | -0.136 | 0.8915 |
| -3 | 0.0017 | 1.609 | 0.1076 | -0.0027 | -1.048 | 0.2945 |
| -2 | -0.0007 | -0.287 | 0.7741 | -0.0041 | -1.712 | 0.0869 |
| -1 | 0.0020 | 0.547 | 0.5847 | 0.0004 | 0.660 | 0.5091 |
| 0 | -0.0039 | -1.092 | 0.2749 | 0.0009 | 0.278 | 0.7810 |
| 1 | **-0.0385** | **-5.537** | **0.0000** | **0.0445** | **6.821** | **0.0000** |
| 2 | **-0.0261** | **-3.921** | **0.0001** | **0.0178** | **3.030** | **0.0024** |
| 3 | **-0.0088** | **-2.339** | **0.0193** | **0.0109** | **2.718** | **0.0066** |
| 4 | -0.0095 | -1.957 | 0.0503 | 0.0066 | 0.667 | 0.5045 |
| 5 | -0.0038 | -1.749 | 0.0803 | 0.0040 | 0.984 | 0.3252 |

*Notes*: The table presents means of one-minute abnormal returns of the ATX in the clusters of announcements of good and bad U.S. macroeconomic news in the period January 2007–December 2013. The results of the Kolari-Pynnönen rank test are also presented.

of the ATX to both kinds of news is significant just after the event. In the first minute after a bad-news announcement the ATX decreases by about 0.039% (with *p*-value $\cong$ $\cong 3\times10^{-8}$), while after an announcement of good news it increases by about 0.045% (with *p*-value $\cong 9\times10^{-12}$). A reaction of ATX returns significant at the 5% level is observed up to three minutes after news announcements. The insignificance of mean abnormal returns in both clusters before the announcements confirms the "*calm before the storm"* effect.

In both clusters of bad and good news, the largest, in absolute value, mean of abnormal returns is observed in the first minute after news releases. This suggests that, irrespective of the information content, the strongest reaction of investors on the VSE takes place in the first minute after a news release. The Kruskal-Wallis test confirms a significant difference in the distribution of $AR_{i1}$s and the distribution of $AR_{it}$s for each $t = 2,\ldots,5$ for both bad- and good-news clusters. For abnormal returns from the bad-news cluster, the Kruskal-Wallis statistics vary from 5.4 for a comparison of $AR_{i1}$s with $AR_{i2}$s to 28.9 when the distribution of $AR_{i1}$s is compared with the distribution of $AR_{i5}$s. Similarly, in the good-news cluster the Kruskal-Wallis test statistics vary from 17.2 to 49. These results confirm that investor reaction in the first minute after U.S. macroeconomic news announcements is significantly stronger than it is later in the event window.

A comparison of $\bar{AR}_1$ in both clusters suggests a stronger reaction of investors to good-news announcements. The Kruskal-Wallis test does not reject the null hypothesis of the equality of distributions of $AR_{i1}$s implied by good news and $-AR_{i1}$ implied by bad news ($KW \cong 1.02$ with *p*-value $\cong 0.312$). This indicates a symmetric reaction to good- and bad-news announcements.

The results of the above event study indicate that the ATX reacts as soon as unexpected bad or good U.S. macroeconomic news is released irrespective of the content (good or bad) of information. This is in line with the results of Dimpfl (2011) regarding the reaction of the DAX index (and other papers mentioned in the previous sections) and it proves the high efficiency level of the Vienna Stock Exchange.

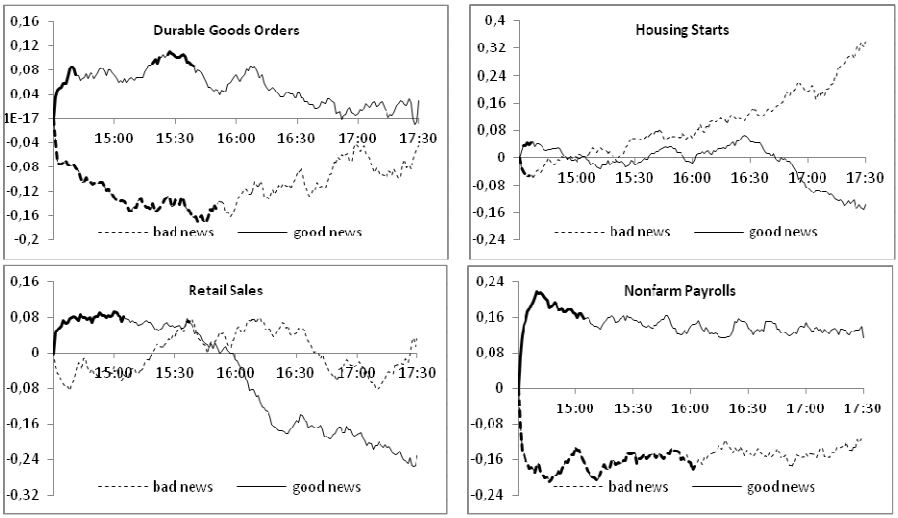
### 4.3 The Duration of the Impact

To describe the total effect of U.S. macroeconomic news announcements for $t \geq 1$, we analyze the behavior of cumulative abnormal returns $CAR_{i\tau}$ given by (9). As mentioned in the previous section, $CAR_{i\tau}$ describes the total cumulative impact of the $i$-th announcement on the abnormal behavior of ATX returns from the first minute to the $\tau$-th minute after a news release. To make the analyses of the impact of each macroeconomic indicator comparable, we consider two groups of announcements: those released at 14:30 CET and those released at 16:00 CET. The first group consists of the DGO, RS, NFP and HS announcements, while the second group contains CC, EHS and NHS announcements. We exclude all IP announcements, as they are usually released at 15:15 CET, and we also exclude CPI and PPI announcements, as their effect on the ATX is insignificant. To show changes in ATX returns after the announcements of different U.S. macroeconomic indicators, we analyze the cumulative reaction of ATX returns up to 17:30 CET, when continuous trading on the VSE ends. In the group of announcements released at 14:30 CET we analyze $CAR_{i\tau}$s for $\tau = 1,\ldots,180$ and for later announcements we consider $CAR_{i\tau}$ for $\tau = 1,\ldots,90$.

*Figure 1* presents the means of cumulative abnormal returns ($\overline{CAR}_\tau$) implied by bad and good news contained in DGO, HS, RS and NFP announcements. The thick parts of each graph indicate the significance of $\overline{CAR}_\tau$ at the 5% level. These graphs show three different types of cumulative reaction of the ATX to U.S. data announcements. In general, there is a very strong reaction just after the event. Later, the pattern of mean cumulative abnormal returns differs. When DGO above consensus is announced, the cumulative impact is significant in the first 12 minutes after a news release. After about one hour, $\overline{CAR}_\tau$ slowly decays to zero. The cumulative impact of DGO below consensus is significant for much longer, up to 15:50 CET. However, after this time, it also weakens and $\overline{CAR}_\tau$s tend to zero. The reaction of the ATX returns to HS and RS announcements is quite different. After a significant reaction in the first minutes, a reversal is visible. After announcements of good news, $\overline{CAR}_\tau$s drop to negative values, whereas $\overline{CAR}_\tau$s become positive after announcements of bad news (for example, $\overline{CAR}_{180} \cong 0.35\%$ after HS announcements below consensus).

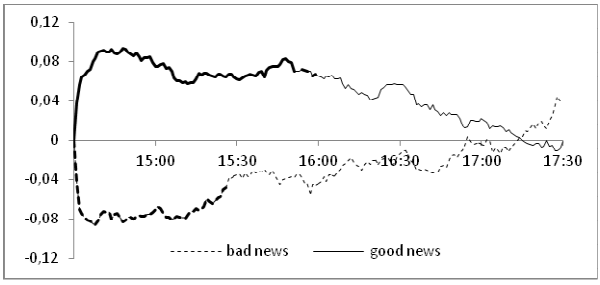
Another reaction pattern is observed after releases of the Employment Report. After the release of good news, when NFP is greater than consensus, the means of cumulative abnormal returns remain significant up to 15:04 CET. Then they stabilize at a level of about 0.14%. After a release of NFP smaller than expected, $\overline{CAR}_\tau$s

**Figure 1 Cumulative Impact of U.S. Macroeconomic News Released at 14:30 CET**




*Notes:* The figure presents means of cumulative abnormal returns of the ATX in the three-hour window after the U.S. macroeconomic news release about Durable Goods Orders (top left panel), Housing Starts (top right panel), Retail Sales (bottom left panel) and Nonfarm Payrolls (bottom right panel). The thick parts of each graph indicate significance of $\overline{CAR}_\tau$ at the 5% level.

**Figure 2 Cumulative Impact of Good and Bad U.S. Macroeconomic News Announced at 14:30 CET**

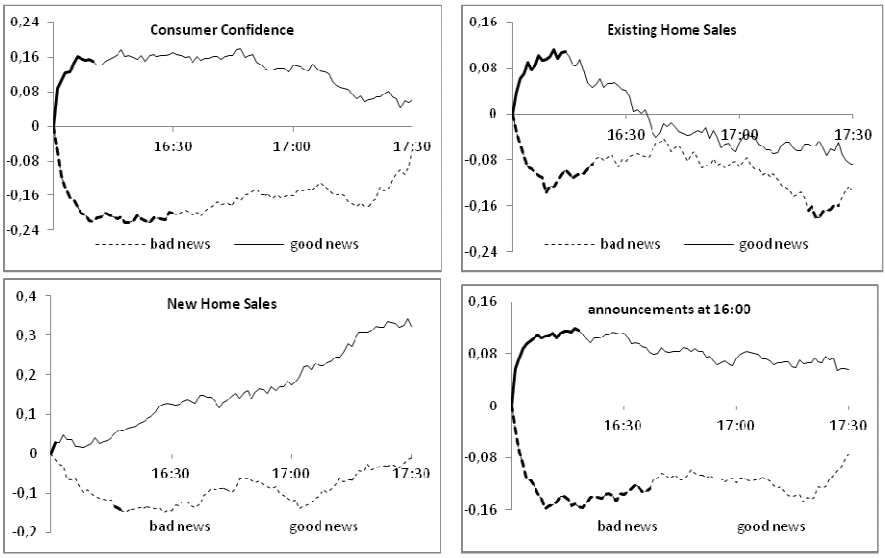



*Notes:* The figure presents means of cumulative abnormal returns ( $\overline{CAR}_\tau$ ) of the ATX in the three-hour window after announcements of good and bad U.S. macroeconomic news. The thick parts of each graph indicate significance of $\overline{CAR}_\tau$ at the 5% level.

remain significant for longer, even up to 15:33 CET. Then, a very slow increase up to -0.1% at 17:30 CET can be observed.

These three types of cumulative behavior of the ATX, together with the reaction of the ATX to inflation announcements, result in the pattern of reactions to all U.S. macroeconomic news announcements released at 14:30 CET presented in *Figure 2*. In general, good news from the U.S. economy greatly increases the ATX level in the first few minutes after a news release. The total impact of good news remains significant even up to 15:48 CET. Then the mean of cumulative abnormal returns of the ATX decreases to zero and after 17:00 CET there are even negative

**Figure 3 Cumulative Impact of U.S. Macroeconomic News Released at 16:00 CET**



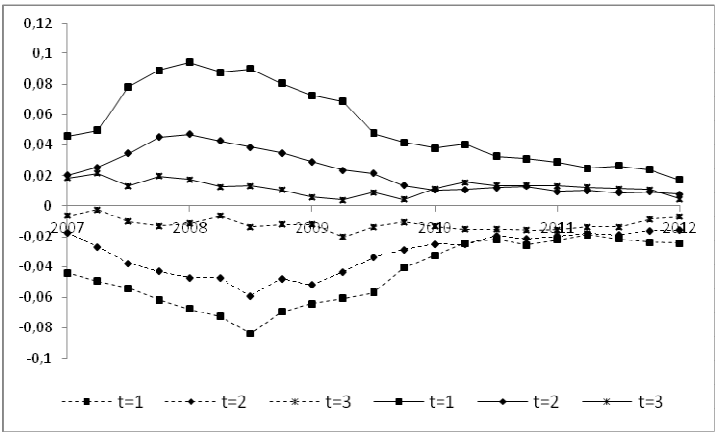

*Notes:* The figure presents $\overline{CAR}_\tau$ of the ATX in the 90-minute window after the U.S. macroeconomic news release about Consumer Confidence (top left panel), Existing Home Sales (top right panel), New Home Sales (bottom left panel) and all the news released at 16:00 (bottom right panel). The thick parts of each graph indicate significance of $\overline{CAR}_\tau$ at the 5% level.

values of $\overline{CAR}_\tau$. This means that the total effect of good-news announcements becomes negligible by the end of a trading session (*mean reversion process*). Bad news also implies rapid changes in the ATX just after 14:30 CET. Then the means of cumulative abnormal returns are significant for about an hour. However, at approximately 14:15 CET $\overline{CAR}_\tau$s start to slowly increase, reaching 0.04% at 17:30 CET. Thus, in general, the cumulative effect of bad news on the stocks listed on the VSE disappears before the end of the trading day.

The above analysis indicates that, in general, U.S. macroeconomic news announcements have a strong impact on the behavior of investors on the VSE only in the first minutes after a news release. This leads to significant changes in the ATX. These disturbances, however, decay with time. At the end of a trading session on the VSE, no effect of the announcements is present. This suggests overreaction of investors on the VSE to U.S. macroeconomic news announcements.

There is a similar reaction of cumulative abnormal returns after news released at 16:00 CET. Their means are presented in *Figure 3*. The only visible exception is cumulative abnormal returns after NHS above consensus, where $\overline{CAR}_\tau$s constantly increases to about 0.33% at 17:30 CET. However, the Kolari-Pynnönen test does not confirm the significance of these $\overline{CAR}_\tau$s. This is probably due to the small amount of good news about NHS taken into account. When we restrict our attention to all news released at 16:00 CET, the total effect of the announcements, measured by the values of $\overline{CAR}_\tau$, does not diminish as it does for announcements at 14:30 CET. For example,

**Figure 4 Changes in the Reaction of the ATX to Good and Bad News from 2007 to 2013**




*Notes:* The figure presents changes in means of abnormal returns $\overline{AR}_\tau$ of the ATX for $t$ = 1,2,3 in subsequent two-year subperiods. Reaction to bad news—dashed lines, reaction to good news—solid lines.

after announcements of good news $\overline{CAR}_\tau$ s stabilize at about 0.06%–0.07%. However, when we take into account the variability of cumulative abnormal returns, all $\overline{CAR}_\tau$ s after good- and bad-news announcements are insignificant at least in the last 45 minutes before the end of the trading day. As in the earlier case, this confirms that U.S. macroeconomic news affects stock prices only in a short horizon and, in general, its effect disappears by the end of a trading session.

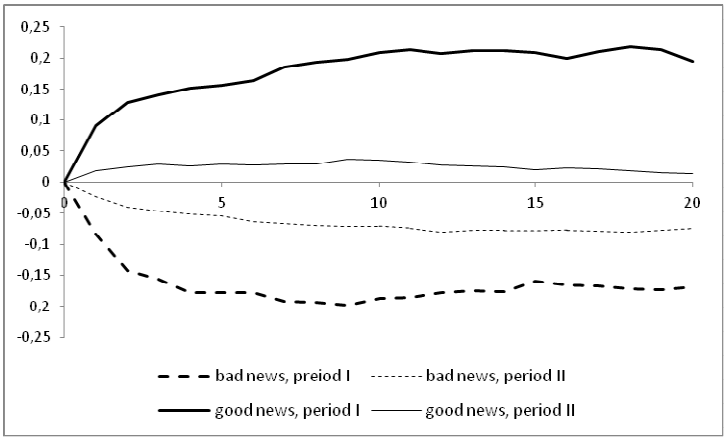
### 4.4 Reaction in Sub-Periods

The results from the previous subsection indicate an immediate reaction of the ATX to U.S. macroeconomic news announcements. However, when interpreting these results we must take into account that the period under study in not homogeneous. It includes the global financial crisis and the subsequent period of stabilization. To describe changes in the reaction of the VSE to U.S. data announcements, we study it in two-year sub-periods. We consider two-year sub-periods because a two-year period contains enough events (U.S. macroeconomic data announcements) to ensure the necessary testing power. The first sub-period starts on 2 January 2007, i.e. at the beginning of the first quarter of 2007. The next starts at the beginning of the second quarter of 2007. Subsequent sub-periods begin with the next quarter. The last sub-period is from 1 January 2012 to 31 December 2013.

In each of the 21 sub-periods described above, there are about 180 announcements of unexpected news from the U.S. economy and they fall almost equally into clusters of good and bad news. However, at the beginning of the period under study the amount of bad news slightly dominates. This similar number of events allows us to compare the results of the event study in each sub-period.

First, we focus our attention on changes in abnormal returns just after news announcements. *Figure 4* illustrates changes in the means of ATX abnormal returns

**Figure 5 Changes in the Cumulative Reaction of the ATX to Announcements of Good and Bad U.S. Macroeconomic News**




*Notes:* The figure presents the averages of cumulative abnormal returns of the ATX in the event window induced by bad and good U.S. macroeconomic news in two periods: July 2008–June 2010 (period I) and January 2012–December 2013 (period II).

in the first three minutes after bad-news (dashed lines) and good-news (solid lines) announcements. On the X axis we label the beginning of each two-year sub-period.

*Figure 4* is in line with the previous results indicating that the strongest changes in abnormal returns are in the first minute after news announcements. A comparison in sub-periods also indicates changes in reaction patterns during the crisis. The highest value of $\overline{AR}_1$ implied by good news is observed in the period from January 2008 to December 2010, while the largest absolute value of $\overline{AR}_1$ implied by bad news is in the period from July 2008 to June 2010. In recent sub-periods, the absolute values of abnormal return averages decrease, indicating a weakening of investor reaction to U.S. news announcements. The Kruskal-Wallis test confirms the difference between distributions of abnormal returns in the first minute after news announcements in the sub-periods covering the crisis and in the sub-periods from the end of the whole period.

Despite changes in the averages of abnormal returns after news announcements, their means in the first minute are always significant at the 1% level. Only the duration of these significant reactions changes. Since 2009, the means of abnormal returns are significant at the 5% level in the first three minutes after bad-news announcements. At the end of the period, good news implies significant abnormal returns only in the first and third minutes after news releases. As an illustration of this difference, *Figure 5* presents the averages of cumulative abnormal returns in two sub-periods: from July 2008 to June 2010 and from January 2012 to December 2013.

The above results indicate the difference in the reaction of the VSE to U.S. news announcements during and after the crisis. To describe this difference in greater detail, we study the impact of U.S. data during the crisis and in the post-crisis period. To ensure an adequate number of events in each period, the crisis covers the period from July 2007 to June 2009, while the post-crisis period contains data from July 2009

**Table 5 Reaction of the ATX to Announcements of Good and Bad U.S. Macroeconomic News in the Crisis and Post-Crisis Periods**

| | Crisis | | | | Post-crisis period | | | |
|---|---|---|---|---|---|---|---|---|
| | Bad news (98 events) | | Good news (65 events) | | Bad news (188 events) | | Good news (180 events) | |
| *t* | $\overline{AR}_t$ (%) | *p*-value | $\overline{AR}_t$ (%) | *p*-value | $\overline{AR}_t$ (%) | *p*-value | $\overline{AR}_t$ (%) | *p*-value |
| -5 | 0.0048 | 0.5428 | -0.0081 | 0.0931 | 0.0035 | 0.2257 | 0.0032 | 0.2613 |
| -4 | 0.0027 | 0.9929 | -0.0056 | 0.3214 | 0.0013 | 0.9937 | 0.0013 | 0.5389 |
| -3 | -0.0043 | 0.6940 | -0.0088 | 0.2089 | 0.0034 | 0.0094 | -0.0017 | 0.217 |
| -2 | -0.0011 | 0.5787 | -0.0051 | 0.9377 | -0.0015 | 0.265 | **-0.0036** | **0.0047** |
| -1 | 0.0021 | 0.8822 | -0.0105 | 0.1124 | 0.0019 | 0.4273 | **0.004** | **0.0034** |
| 0 | -0.0050 | 0.0921 | 0.0091 | 0.4261 | -0.0044 | 0.0515 | -0.0023 | 0.9442 |
| 1 | **-0.0509** | **0.0000** | **0.0751** | **0.0000** | **-0.0344** | **0.0000** | **0.0347** | **0.0000** |
| 2 | **-0.0353** | **0.0198** | **0.0333** | **0.0026** | **-0.0229** | **0.0000** | **0.0143** | **0.004** |
| 3 | -0.0084 | 0.2238 | 0.0129 | 0.1959 | **-0.0102** | **0.0004** | **0.0092** | **0.0037** |
| 4 | -0.0108 | 0.1072 | 0.0216 | 0.1147 | **-0.0092** | **0.0299** | 0.0015 | 0.9648 |
| 5 | **-0.0092** | **0.0371** | **0.0081** | **0.0317** | 0.0011 | 0.4683 | 0.0033 | 0.3319 |

*Notes*: The table presents means of one-minute abnormal returns of the ATX in the reaction to announcements of good and bad U.S. macroeconomic news from July 2007 to June 2009 (crisis period) and from July 2009 to December 2013 (post-crisis period). The results of the Kolari-Pynnönen rank test are also presented.

to the end of 2013. The length of these periods allows only application of event study in two clusters of bad and good news. There are not enough announcements of any single macroeconomic indicator to perform reasonable analysis similar to that presented in *Tables 2* and *3*. Before viewing the analysis of the results presented in *Table 5,* one should note the difference in numbers of events in the crisis and post-crisis clusters, which may influence the power of the tests. Comparison of the means of abnormal returns confirms the above observation that investor reaction to U.S. macroeconomic news announcements weakened after the crisis. That is visible for both bad and good news. On the other hand, abnormal returns of the ATX remain significant for a longer time after the crisis. In the later period, significant $\overline{AR}_t$ are also observed before news announcements, though they have different signs.

## 5. Conclusions

In this paper we examine the impact of several U.S. macroeconomic news announcements on the stock prices quoted on the Vienna Stock Exchange. We study the impact of announcements about ten macroeconomic indicators: the Consumer Price Index (CPI), the Producer Price Index (PPI), Industrial Production (IP), Retail Sales (RS), Durable Goods Orders (DGO), Nonfarm Payrolls (NFP), Existing Home Sales (EHS), Housing Starts (HS), New Home Sales (NHS) and Consumer Confidence (CC). All computations are based on one-minute log-returns of the ATX from 2 January 2007 to 31 December 2013. The speed and strength of price reactions, the duration of price adjustments after news announcements and other features of stock price responses reflect the level of the informational efficiency of the VSE.

A significant reaction just after the release of U.S. macroeconomic news is expected in light of EMH in the case of efficient markets. An event study along with the non-parametric generalized rank test of Kolari and Pynnönen (2011) confirms that investors on the VSE react significantly and very quickly in just the first minute after a news release and this reaction remains significant for about three minutes. This is in line with previous results indicating a fast and significant reaction of European developed markets to macroeconomic news (e.g. Harju and Hussain, 2011; Dimpfl, 2011). The strongest reaction is induced by announcements of NFP, which is the first macroeconomic indicator published each month. The weakest reaction is observed after inflation announcements. The reaction in the first minute after news announcements is significantly stronger than later in the event window. In general, this initially strong reaction decays with time and the cumulative effect of macroeconomic U.S. news announcements disappears before the end of a trading session. In general, abnormal returns in the period before announcements are insignificant and a *"calm before the storm"* effect is observed. All these results indicate a high level of informational efficiency of the Vienna Stock Exchange with respect to the most important U.S. macroeconomic announcements.

The event study performed in sub-periods reveals a significantly stronger reaction of the ATX to U.S. news announcements during the crisis of 2008. In the post-crisis period, investors on the VSE react to unexpected news about the U.S. economy much more calmly than during the crisis and just after it. However, this reaction remains significant for a longer time.

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