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THE REACTION OF THE CEE FINANCIAL MARKETS TO THE POLICIES OF THE FEDERAL RESERVE

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Abstract

This paper considers the reaction of financial markets in Central Eastern Europe (CEE) to the actions of the Federal Reserve of the United States (FED). The study covers years from 2000 until 2015, and analyses both equity and bond markets. The authors first estimate how surprising each FED decision was over the sample period by using federal funds futures and Eurodollar contracts. Using these calculations, an event study of the most surprising events is performed, followed by a regression analysis which determines the average relationship between FED events and the reaction of financial markets in CEE. The authors find that in the CEE area, stock markets react to FED announcements, but bond markets do not. In the sample of eight countries, on average five equity markets reacted significantly to unexpected changes in effective federal funds rate. The reactions are stronger in the post-crisis period, when monetary policy was more aggressive.

Keywords: the Federal Reserve, CEE financial markets, expectations, surprise factor, event study

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1. Introduction

The Federal Reserve is the most important central bank in the world and its policies are not limited to the borders of the US. Their decisions often have an impact on many other countries as well. For example, a small change in US interest rates can lead to significant capital movements, which in turn change prevailing interest rates abroad. This paper seeks to find out whether stock and bond markets react to the FED's decisions in the CEE area.

More specifically, this paper analyzes how financial markets react to unexpected changes in the federal funds rates. The federal funds rate is the rate at which banks can borrow reserves from other banks. The FED is the body that controls this rate and its importance lies in the fact that it determines many other interest rates and financial asset prices. Financial markets react very quickly to events such as decisions by the FED. A transaction of selling a US treasury bill and buying a Lithuanian government's bond happens instantaneously. Thus, the effect of monetary policy on financial markets is quick, contrary to the real economy where prices, wages and employment change slowly. The study also covers a period when the FED pursued a large scale open market operation - quantitative easing (QE). It is a program during which a central bank buys private and public bonds from the open market, mostly from private banks. As a result, prices of bonds increase and the interest rates decrease. In general, a central bank's aim is to provide low, stable inflation and high employment rates. Those effects will take place in the long run and are not studied in this paper.

The focus of this study are the financial markets of the Central Eastern Europe (CEE). In this study Central Eastern Europe consists of: the Czech Republic, Estonia, Hungary, Lithuania, Latvia, Poland, Slovakia and Slovenia. The countries are chosen due to their historical similarity, as they were part of the Eastern Bloc and since their economies and financial markets started to develop at the same time. CEE is also a term the OECD uses for grouping these countries (OECD, 2001).

The impact of the FED's policies has been studied before. It has been shown that their actions have domestic and international effects (Hausman, Wongswan (2006), Kishor, Marfatia (2012). However, most studies have concentrated on the US, emerging markets and developed European countries, leaving CEE region outside the scope of academic research. Furthermore,

few papers have considered how international markets react to changes in expectations in the post-crisis period, leaving an important gap in the literature.

It would be reasonable to assume that investors both in the US and in the CEE follow news announcements about the FED's monetary policy. However, the question becomes whether or not investors in the CEE incorporate this information in their decision making. On one side, CEE financial markets are not highly developed, hence it might be the case that they are insulated from outside monetary policy shocks. On the other hand, in the past years the global financial markets have become more interconnected, leaving very few safe heavens, where one could escape cross-border effects.

Taking this into account, this study aims to answer the following research question**: Do CEE financial markets react to the FED's monetary policy decisions?** In order to answer the research question the authors use federal funds futures contracts and Eurodollar contracts to estimate how surprised the markets were by the decisions of the FED. The events are Federal Open Market Committee (hereinafter FOMC) meetings where decisions about monetary policy are made, post-meeting minute releases and others. Then the authors assess whether the CEE markets reacted to those events by using event study analysis and time series regressions models.

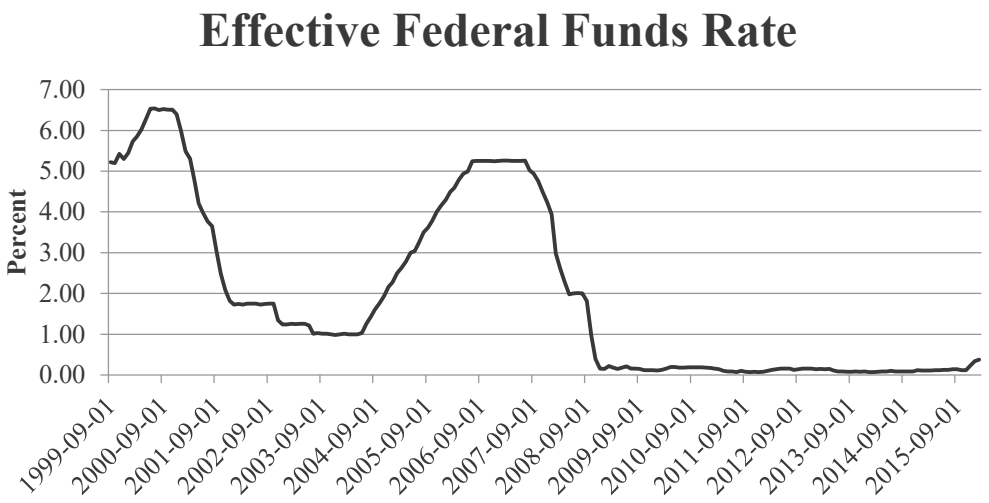
The work is structured as follows. The section below includes an overview of the FED' policy over the sample period. Section 2 describes the literature about the FED's impact on financial markets in domestic and foreign markets. Section 3 provides a description of methodology of data collection and analysis. Section 4 presents the result analysis related to surprise factor calculations, while section 5 covers the result analysis of effects on stock and bond markets. Section 6 discusses the key takeaways of the result analysis. Section 7 provides limitations of the study. Finally, Section 8 provides broader conclusions about the study.

1.1. The policy of the FED during the time of study

With the aim of providing context about the time period the authors analysed, this paragraph describes the major events that happened during this time and the way the FED reacted. This paper covers about 16 years of monetary policy by the FED and it can be broadly divided into three periods: the aftermath of the tech bubble and build up to the crisis, the reaction to the Great Recession and the era of quantitative easing. In order to give a snapshot of the time period, the authors include data from the Federal Reserve Bank of St. Louis which shows the

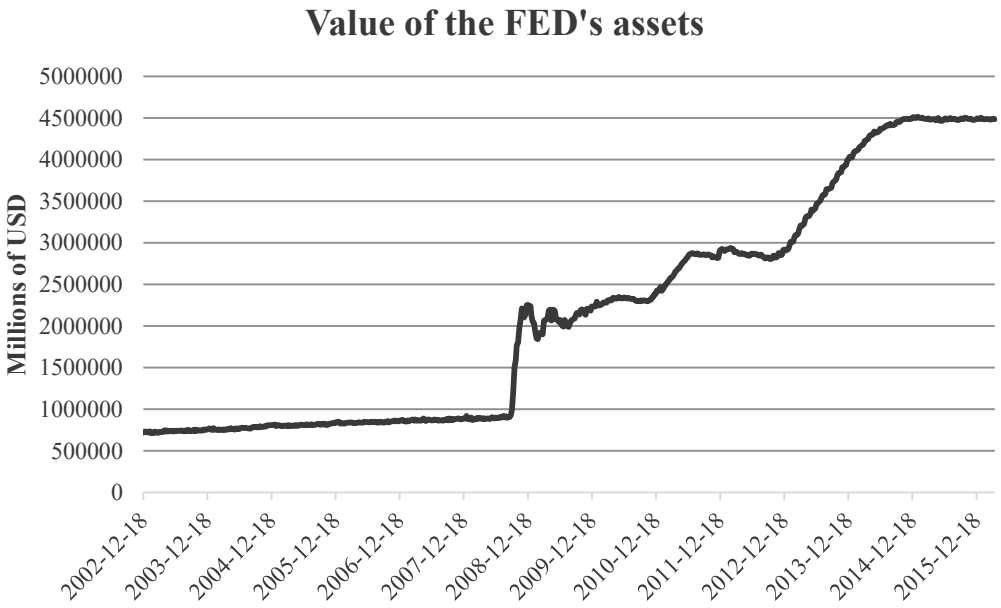
effective federal funds rate over time (Figure 1). It is the rate at which banks lend reserves to one another overnight. It is lowered during recessions and increased when there is a threat of an overheating economy.

Figure 1. Effective Federal Funds Rate based on data from the Federal Reserve Bank of St. Louis. Created by the authors.



After the tech bubble in 2000, the FED started cutting rates in order to boost economic activity. The recession had been sharp but brief and thus it seemed that the FED had reacted to the economic circumstances correctly. Later, signs of high leverage became apparent in the economy. As it can be observed on the graph, in 2005 the FED was already increasing interest rates to limit excessive borrowing. But the roots of the crisis were deep and merely increasing the federal funds rate would not keep the crisis from happening. The housing market of the US collapsed and the FED needed to cut interest rates once again in order to prevent the recession from doing more damage to the economy. In December 2008 the federal funds rate target was set to be between 0% and 0.25%. While those interest rates stayed there for a very long time, it does not mean that the FED took no action. In order to boost the economy, the FED completed three rounds of quantitative easing from 2009 to 2014. The aim was to bring down long term interest rates (Labonte, 2016). During that time the size of their balance sheet expanded significantly. For comparison, until 2008 the size of their balance sheet was less than 1$ trillion, as shown in Figure 2. It grew to almost 4.5$ trillion by early 2016 (Labonte, 2016).

Figure 2. Value of the FED's assets. Data from the Federal Reserve Bank of St. Louis. Created by the authors.



Although the economy had improved and the FED expected to achieve full employment in 2016, raising interest rates was postponed for a long time, as there was disagreement about the slack in the economy. Finally, the interest rates were increased in December 2015 (Labonte, 2016).

All in all, the period that the authors study has seen a mild recession, a period of stable interest rate increases and the biggest financial crisis since the Great Depression. The authors of this paper analyze whether or not the CEE financial markets have reacted to fluctuations of the interest rates and the expanding balance sheet of the FED.

2. Literature Review

2.1. The impact of the FED's policies on stock markets

The policies of the FED and their impact on the stock market has been studied quite thoroughly. Bernanke and Kuttner (2004), using federal funds futures, estimated the impact that unexpected changes in effective federal funds rate had on the stock market. They find that by unexpectedly cutting the federal funds rate by 25 basis points (0.25%), the stock market on

average gained 1%. The authors explain that this comes through two channels – expected dividends and excess equity returns. Rigobon and Sack (2002) also write about the impact of the federal funds rate changes to the stock market. Their findings are similar to Bernanke's and Kuttner's, but they also found that stock markets are affected significantly on days of FOMC meetings and other important monetary policy events, such as the Chairman's speeches to Congress. The same events, on the other hand, did not have a significant impact on longer-term interest rates. The effect on those interest rates was assessed through the use of Eurodollar futures contracts which can mature more than one year from the event that was studied.

The FED's policy seems to affect US stock markets, but does the same hold for foreign countries? Hausman and Wongswan (2006) use federal funds futures and Eurodollar futures to gauge the surprise factors of FOMC meetings to assess whether unexpected changes have an impact on foreign stock markets. Their sample consists of 49 countries, a mix of highly developed and less developed countries. The authors find that international stock markets react to FOMC decisions and the strength of the reaction depends on how developed the financial markets are and how interconnected they are to the US. This research was completed in 2006 and thus did not include the aftermath of the Great Recession. Kishor and Marfatia (2012) studied the same topic and their data included stock market returns until 2008. They found that emerging markets react to the FED's policy as strongly as European markets. Their sample included only developed European states. A surprising finding was that while at normal times a cut in fed funds rate leads to an increase in stock prices, during times of crisis the effect is the opposite. Overall the two studies indicate that the FED's policies have an impact on foreign stock markets as well. However, the sample included mostly developed countries and did not include the post-crisis period.

One of the most common policy tool used by the FED is an open market operation (hereinafter OMO). During an OMO the FED buys securities from the private market and thus changes the level of reserves that the commercial banks have, in order to affect the interest rates. This decision is made by the FOMC, who meets approximately 8-9 times per year. Theoretical foundations of why an OMO as a monetary policy instrument would work was first articulated by Modigliani and Sutch (1966). While the FED also controls the fed funds rate through OMO's, in this study, the authors consider a policy which is called quantitative easing (QE). It is a large scale OMO during which the FED tries to bring down long term interest rates. In the case of QE,

the FED usually buys government bonds and mortgage backed securities from private banks and gives them reserves in return. The result is an asset-swap which does not increase the net wealth of the private banks. Instead it results with higher demand for government bonds which lowers the interest rates and pushes up bond prices (Roche C.O., 2014). It is important to understand the technical side of this process because QE is often referred to as "money printing", but this terminology provides a false understanding of the process.

The purchase of bonds from secondary markets should result in higher investment, stock market valuations and investor confidence, due to the wealth effect and change in discount rates. The wealth effect occurs when investors perceive themselves to be wealthier due to increased asset prices, and their confidence in the economy increases. The discount rate effect comes from the fact that the Treasury bond yield (risk free rate) decreases as the demand for those bonds increases. As a result, the required return on equity and debt will be lower and future cash flows will be discounted at a lower rate. The effect then transmits into output, employment and prices (Akhtar, 1997, Bernanke, Kuttner, 2004). QE can also change expectations of the future state of the economy and the exchange rate of the USD versus other currencies (Roche C.O., 2014).

The scale and size of the FED's policy is not the only factor that explains changes in financial markets. The communication and surprise factor of the policy matters as well. For example, Wright (2011), using Treasury future derivatives around the QE announcement days was able to estimate the magnitude of how unexpected the announcements were. Bernanke and Kuttner (2004) hypothesize that unanticipated rate changes affect the stock market more than anticipated ones. This indicates that if the FED's actions are predictable, the impact should be minimal. This introduces a new element into the FED's work: communicating its intentions and decisions clearly so that the markets would know how to incorporate information into prices. If the communication is unclear, surprises are bound to happen and during times of crisis, it is not favorable. Hayo and Neuenkirch (2010) found that speeches given by officials from the Federal Reserve explain target rate decisions rather significantly. The notion is sometimes called "forward guidance", as the FED communicates clearly its intentions about target rates and gives confidence to the investors that there will be no unanticipated moves. Following this conclusion, this paper concentrates on the FED's unexpected decisions, as the predictable decisions are priced into markets beforehand. Furthermore, the authors hypothesize that financial markets will react to unexpected events more significantly.

2.2. Empirical evidence of domestic and foreign effects of Quantitative Easing

To this day, most of the empirical studies have looked into short term effects of the FED's recent policies. This is due to the fact that unconventional monetary policy has been implemented only recently with unclear effects. Among the studies that analyzed short term effects, Krishnamurthy and Vissing-Jorgensen (2011) found that buying mortgage backed securities (MBS) lowered MBS yields and did the same for corporate yields. Purchases of US treasuries also lowered treasury rates, which are considered to be "risk-free". This effect resulted in lowered discount rates and higher asset prices. Moreover, Gagnon et al. (2011) show that around the announcement period of QE, long-term treasury and mortgage backed security yields were affected significantly. On the other hand, Villanueva (2015) shows that while QE pushed up stock prices, it is not the sole and most important factor. Indeed, strong stock fundamentals were also supportive of the increase in stock prices.

Aside from domestic effects of QE, one might consider whether the FED's policy had unintended international consequences. Even though the financial crisis of 2007-2008 damaged global financial markets, the interlinkages between still remained important. One of the first papers to consider international effects of QE is Neely (2015). This paper showed that government bond yields, stock market indices and exchange rates in advanced economies (Australia, Canada, Germany, Japan and UK) moved above their historic norms during important QE announcements. An important conclusion of this work is that the FED's announcements to expand QE had a stronger impact on bond yields than announcements to limit QE. In support of these transmission effects to other markets, Glick and Leduc (2012) found QE announcements affecting commodity prices via a signaling channel. In other words, their findings suggest that aggressive QE announcements were associated with a negative future economic outlook, resulting in negative impact on commodity prices. Finally, Bauer and Neely (2014) find that QE had a non-uniform impact on the financial markets of advanced economies. Thus, decisions about increasing the scale of quantitative easing could mean a negative effect on the CEE markets, as it can be interpreted as a more negative outlook on the world economy.

More recently many studies have attempted to analyze the effect that the FED's policy had on the emerging market economies (EME). Ahmed and Zlate (2014) find that QE had a significant positive impact on capital inflows to the EME (the sample included Brazil, China, India, Russia and South Africa, among others). As QE lowered interest rates in the US, investors sought for higher yield in other countries. This consequently led to a creation of an additional layer of interconnectedness. Chen et al. (2015) also showed that the international spillovers of QE to stock markets were much stronger in EMEs than in advanced economies. Similarly, Kang and Suh (2015) find that the reversal of the FED's stance on monetary policy (from expansionary to contractionary) resulted in negative effects to EMEs, especially to those that experienced larger capital inflows during QE. Other studies, similarly to the case of advanced economies, have found that the impact to EMEs is not homogeneous. Chen et al. (2014) find that those EMEs which had stronger macroeconomic fundamentals and more liquid financial markets were better equipped to deal with the FED's monetary policy shock. The effect of QE on the emerging markets has been studied quite extensively, but to the authors' knowledge, the surprise factor of different QE announcements has not been taken into account. The authors consider the surprise factor during the QE period in this paper, adding novelty to the subject. Also, the studies that already exist have considered a couple of countries which are in CEE, but this study considers all of them.

2.3. Methodology used in the literature

There are two major methodological approaches that are used in analysing the impact of the FED's decisions. The first approach is to use time series models. The motivation behind using this method is to account for movements in the markets before the actual decision is made and for interlinkages within the financial sector. For example, different versions of vector autoregressive (VAR) and vector error correction models (VECM) have been used to analyse the international effects of the FED's policy (Bauer and Neely, 2014, Chen et al., 2015). In addition, Kang and Suh (2015) have used panel fixed effect regression models to account for time invariant differences across countries in analysing international effects. The difference in choice of the approach stemmed from the financial indicators that were being studied, for example CDS spreads or interest rates.

However, assuming that the impact of the FED's decisions is priced into financial assets quickly, some have argued in favor of using the event study methodology. Among others, Gagnon et al. (2011) used the event study method to analyse the domestic effects of QE. Neely (2015) applied this approach when analysing the effects of FED's policy on developed international markets, whereas Glick and Leduc (2012), using the same methodology, analysed the impact on commodity markets. The event study method is also used when analysing policy impact of other central bank interventions. Among others, Joyce et al. (2011) looked into the impact of the Bank of England's QE program, whereas Falagiarda and Reitz (2015) analysed the European Central Bank's policy impact. In most cases researchers analyzed how the financial indicators such as bond yields changed 1 or 2 days after the event.

Apart from direct effect analysis, others have tried to measure the surprise factor of FED's policy. The surprise factors would indicate how unexpected the decision of the FED was to financial markets. As investors price in their expectations to stock and bond prices, unexpected decisions from the FED will make those prices fluctuate. To uncover the surprise factor it is common to use the principal component analysis (PCA). One of the first papers to consider using this approach is Gürkaynak, et al. (2005). The authors of this paper used the federal futures contracts of the current month and 3-month ahead contract of each FED event in combination with Eurodollar futures for two, three and four quarters ahead. Once the futures contract price movements are identified, PCA analysis is used to find common factors in these price movements. These factors are separated into two factors: target and path, where target factor is related to changes in current federal funds rate and path factor accounts for future monetary policy path. More recent papers which used this methodology (Doh and Connolly (2013) and Berge and Cao (2014) have argued that during the QE period, when federal funds rates have reached a long lasting low point, it is important to include wider and more forward looking contract prices, for example, taking Eurodollar futures up to ten quarters ahead of the FED event.

3. Methodology

Methodology that was used in this study can be separated into three parts: estimation of the FED's monetary policy surprise factors, event study, analysing the CEE financial market

reaction to the most surprising FED events, and time series regression analysis, used to find more general links between CEE financial markets and the FED's policy surprise factors. Both event study and time series analysis build upon the estimation of monetary policy surprise factors. The authors have decided to use personal calculations of surprise factors to maintain consistency of the research, but the method of calculation is based on the papers of Doh and Connolly (2013), and Gürkaynak, et al. (2005).

3.1. Monetary policy surprise factors

Estimation of the monetary policy surprise factors is based on price movements of two types of futures contracts: federal funds futures and Eurodollar futures. The structure of federal funds futures is such that one party pays the contract price, while the other receives the average effective federal funds rate over a specified month. These contracts are issued on a monthly basis, two years before settlement, and are traded on a daily basis (CME Group, n.d.). All things considered, the federal funds futures price should reflect market expectations about the average effective federal funds rate over a specified month. Extending this intuition, it can be said that movements in the contract prices should reflect changes in market expectations about the average effective federal funds rate. For this reason, the authors used daily price movements of these contracts around FED events to capture how unexpected the FED's decisions were.

In addition to federal funds futures, the authors also considered Eurodollar futures. Eurodollar futures are similar in their structure to federal funds futures, where one party pays the contract price, while the other party pays the average three-month Eurodollar interbank time deposit rate (Labuszewski, 2013). The advantage of including Eurodollar futures is that compared to federal funds futures, Eurodollar futures cover more periods ahead of the FED events. It is then possible to capture in greater detail, changes in market expectations about the trajectory of the FED's monetary policy. For clarity, Eurodollar contracts have nothing to do with the euro as a currency.

Using these future contracts, the authors calculated one day price movements of these securities around FED events. The list of FED events is based on Doh and Connolly (2013), which includes events from 1997 up to 2013. In addition, the authors of this paper added events for the years 2014 and 2015, following the same selection procedure as Doh and Connolly

(2013). These events consist of FOMC meetings, releases of FOMC meeting minute or other events related to FED's policy making. For each event, the authors calculate price changes of federal funds futures contract of the month, when the event happens, and for the month when the next FOMC meeting occurs. For Eurodollar future contracts, the authors have taken quarterly contracts from 2-quarters up to 10-quarters ahead the event. In total 11 (2 federal funds and 9 Eurodollar futures) securities were taken for the monetary policy surprise factor calculation.

Due to the nature of federal funds contracts, one day changes in the contract price does not reflect the full change in expectations about the federal funds rate. To illustrate this point, consider a FED event which happened on the 21st of September. The future contract is set up so that one party pays the average federal funds rate. However, the federal funds rate could have only changed on the 21st of September. This means that for 21 days one party would be paying the old rate, while for the remainder of the month, it would be paying the new rate. In this case we are only interested in the remaining part. Thus when calculating change in expectations about the current federal funds rate, which we denote $mp_{1,t}$, we adjust the change in federal funds futures price

$$mp_{1,t} = \left(ff_{1,t} - ff_{1,t-1}\right)\frac{D_1}{D_1 - d_1} \qquad (1)$$

where $ff_{1,t} - ff_{1,t-1}$ is the one-day price change of federal funds futures price for the current month at event date, d_1 is the day of the month when event happened and D_1 is number of days in that month (Gürkaynak, et al. 2005). A similar adjustment has to be made for calculating change in expectations about the future federal funds rate for the next FED event, which we denote $mp_{2,t}$

$$mp_{2,t} = \left[\left(ff_{2,t} - ff_{2,t-1}\right) - mp_{1,t}\frac{d_2}{D_2}\right]\frac{D_2}{D_2 - d_2} \qquad (2)$$

where $ff_{2,t} - ff_{2,t-1}$ is the one-day price change of federal funds futures contract for the month, when the next FOMC meeting happens, at event date, d_2 is the day of the month of the next FOMC meeting and D_2 is number of days in that month (Gürkaynak, et al. 2005). For Eurodollar futures, similar adjustment is not necessary, as these contracts are much more forward looking, and are estimated on a quarterly basis, hence one-day price changes are used to capture change in expectations.

Afterwards, a matrix is constructed (N x X), where rows represent FED events (N) and columns represent calculated changes in expectations ($mp_1$and mp_2) and Eurodollar futures prices (X). In the next stage principal component analysis is used, where the previously

described matrix is decomposed into a set of orthogonal vectors F_i, $i = 1, \ldots X$, with length N. In this case, F_1 is the vector that has the highest explanatory power for the original matrix. F_2, is the vector that has the highest explanatory power for the residuals of the original matrix, after projecting each column (X) on F_1, and so on. Only the first and second principal components were taken for further analysis. The reason for using principal component analysis in this case is that we want to capture common movements across the federal funds futures and Eurodollar futures contracts.

To allow for a more elaborate analysis, these two components are rescaled and rotated in such a way, that the first component is only correlated with the federal funds futures of the current month ($mp_{1,t}$), while the second component is correlated with remaining securities. In this way we can define the first component as the target factor – related to surprises about the change in expectations about the current federal funds rate. The second component can be defined as the path factor – related to the change in the expectations about trajectory of future monetary policy.

Mathematically, this means that we transform our matrix F of the first two principal components (N x 2, where N is the number of events) using scaling factor matrix U (2 x 2) to calculate target and path factor matrix Z (N x 2). In Appendix A the authors provide a more detailed explanation of how matrix U was estimated.

$$Z = FU \tag{3}$$

$$U = \begin{bmatrix} \alpha_1 & \beta_1 \\ \alpha_2 & \beta_2 \end{bmatrix} \tag{4}$$

3.2. Event study

After identifying the surprise factors of each FED event, in the next step of the analysis the authors ranked the most surprising events in terms of target and path factors. By taking the most surprising events it is then possible to apply the empirical distribution method. This method helps to determine whether CEE financial market movements around the most surprising events were significant compared to historical norms.

The empirical distribution method has been used before in analysing the effects of FED decisions, for example Neely (2015), Glick and Leduc in (2012). In most cases, the analysis consists of calculating 1-day or 2-day equity market returns and bond yield changes for a sample

period and comparing realized returns on event dates with the estimated historical return distribution. For the analysis of the CEE financial markets this study considered 1-day, 3-day and 5-day price movements, to reflect that it might take a longer time for CEE financial markets to incorporate new information about the FED's announcements.

An important consideration that requires attention is the length of the historical period to which the observed return on event day would be compared to. Following procedure used in the literature, the authors have chosen to take a 5 year period, beginning from 2006.07.01 to 2011.07.01. The motivation of this sample is two-fold. First, this period includes the most significant FED events that have been found in the study sample (explained in the section below). Second, it is common that for historical return estimation a sample of approximately 5 years is taken. The starting date of the sample is usually one year before the earliest FED event included in the sample, while the end date is usually one year after the latest FED event.

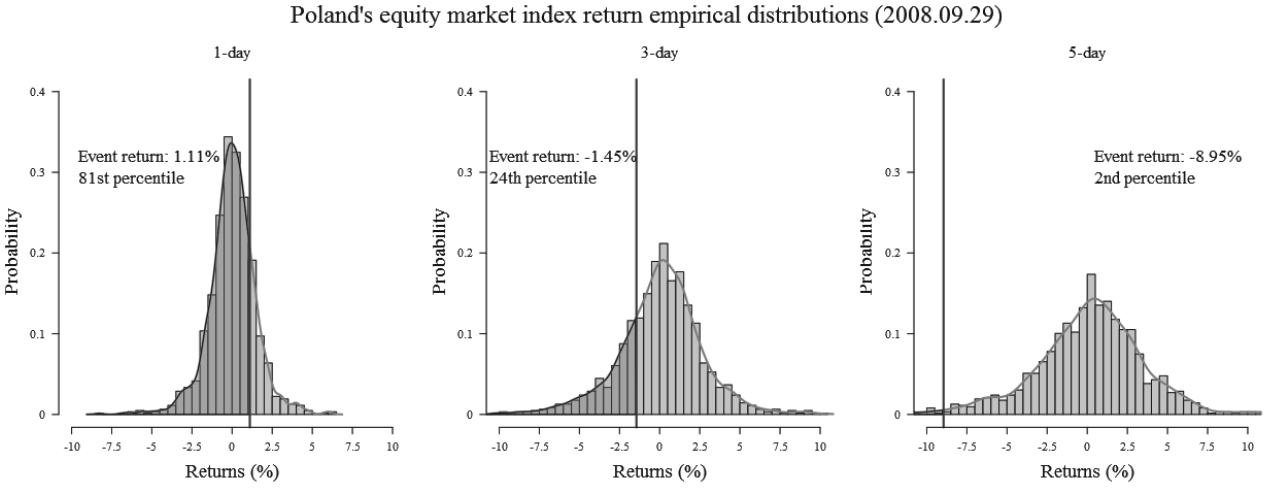
To apply this method the authors first estimate historical 1-day, 3-day and 5-day price changes of respective CEE equity market indices, short-term government bond yields (1-year), and long-term government bond yields (10-year) for 5 years. For equity market returns, denoted R_t, the authors took logarithmic differences in market indices, to retrieve continuously compounded returns

$$R_t = \log(P_{t+1,3,5} - P_t) \qquad (5)$$

where t is the date for which the return is calculated, P_t is the value of the market index at day t.

The historical price movements are then used to estimate an empirical distribution of past returns for each country and for each asset class. Using the empirical distribution, observed returns on significant events days are compared to the historical distribution and a corresponding percentile is calculated. An example is presented in Figure 3. In the example, the returns of Warsaw Stock Index (Poland equity market proxy) on 2008.09.29 are compared with the historical distribution of Warsaw Stock Index returns between 2006.07.01 and 2011.07.01. The vertical line shows where exactly in the distribution observed returns lie. The shaded area represents the historical returns which are smaller than the observed ones. Converting shaded area in terms of percentages, gives us the percentile of observed returns, compared to the historical distribution.

Figure 3. Presentation of how the empirical distribution method would be used for analysing equity market returns and bond yield changes. The three figures show empirical distribution of 1-day, 3-day and 5-day returns. As an example, returns of Poland's equity market index on 2008.09.29 (event date) are presented. The vertical line indicates, where in the distribution the return is. The shaded area represents the percentage of estimated returns, which are below the event return.



3.3. Regression analysis

In the third part the authors use regression analysis to estimate the average relationship between surprise factors and CEE financial market returns. For this purpose a time-series regression model is constructed, where the dependent variable is the CEE financial market return (stock market returns or change in bond yields), denoted R_{it}, is regressed on target and path factors, denoted $target_t$ and $path_t$ respectively. In this analysis, the authors took daily market returns.

$$R_{it} = \beta_0 + \beta_1 target_t + \beta_2 path_t + \varepsilon_{it} \quad (6)$$

Following the procedure used in literature for similar analysis (see e.g. Neely (2015), Doh and Connolly (2013), Gürkaynak, et al. (2005)), the authors used OLS estimation, where beta coefficients for each target and path factor were used to determine, whether, on average, CEE financial markets move in response to changes in target and path factors. In this case the distinction between target and path factors is important, as it allows to distinguish whether CEE financial markets react more to unexpected changes in the current federal funds rate or if the unexpected changes in future FED's monetary policy also matters. The regression analysis was performed for each asset class and for every country separately.

The study sample that was used for the regression analysis included equity market return data for the period between 2000.01.01 and 2016.01.01. For bond market data coverage varied greatly across countries, the sample period for the majority of the countries was between 2008.01.01 and 2016.01.01. For this reason, the analysis of market return data was separated into 3 periods: full sample (2000-2016), pre-crisis period (2000-2007) and post crisis period (2008-2016). This way stock market and bond markets results are comparable. An additional advantage of using such sample separation is that it can be used to compare the results with previous works, similar to Hausman and Wongswan (2006) where target and path factor estimations were used for foreign effect analysis, but only covered the pre-crisis period.

3.4. Data

The list of countries that were included in the sample consists of the Czech Republic, Estonia, Hungary, Lithuania, Latvia, Slovakia, Slovenia, and Poland (OECD, 2001). Due to lack of data Albania, Romania and Croatia were excluded from the sample. The list of market indices that were chosen for the study include Prague Stock Exchange Index, OMX Tallinn Index, Budapest Stock Index, OMX Vilnius, OMX Riga, Slovak Share Index, Slovenian Blue-Chip SBITOP Index, and Warsaw Stock Exchange Index, respectively. For bond data, the authors took zero coupon bond yields of short-term bonds (1-year) and long-term bonds (10-year). Both market index and bond yield data were taken at daily frequency. Contract prices for federal funds futures and Eurodollar futures contracts were taken for the same period and also at daily frequency. Note that each month has a unique federal funds futures contract and each quarter has a unique Eurodollar futures contract. All of the data was retrieved from Datastream, on March 1st, 2016.

4. Surprise factors

The method of calculating the surprise factors was described more thoroughly in the methodology part, thus in this part the authors consider only the results. The target factor indicates unexpected movements in the current federal fund rates while the path factor measures unexpected change in future monetary policy outlook. For the target factor, the intuition of the

surprise factor is following: as an event happens in a given month, then a factor of 1 means that the implied federal funds rate for this month changed by 1 basis point (0.01%). The implied change is derived from the change of that month's federal funds future's price. For the path factor the intuition is not that clear. A surprise factor of 10 would mean a 3 basis-point change in the Eurodollar futures contract, which matures 10 quarters ahead of the event. This is also why the path factor seems to be more volatile compared to the target factor. Thus the surprise factors cannot be compared one to one.

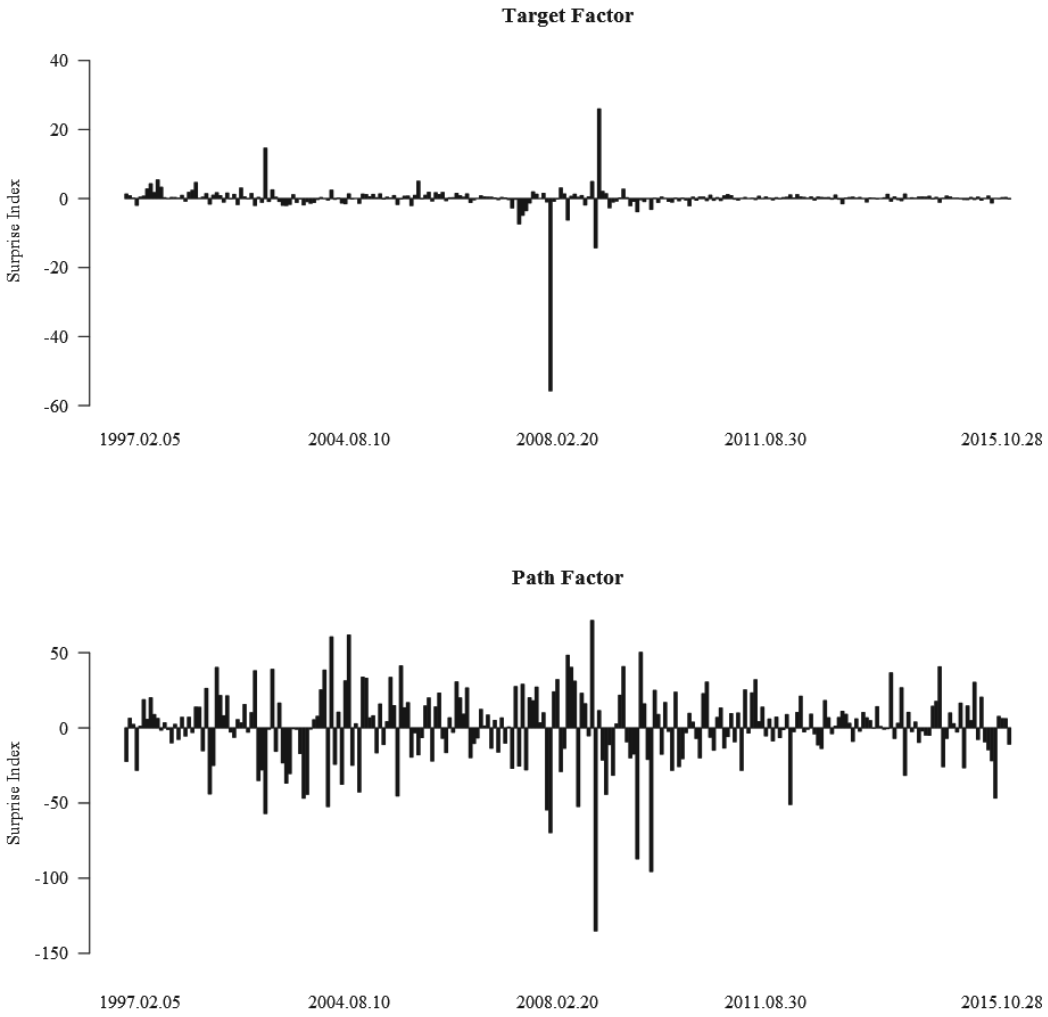
Table 1. Summary statistics of estimated target and path factors.

	Target factor	Path factor
Mean	0.000	0.000
Min	-55.709	-135.079
25%	-0.390	-11.054
Median	0.144	2.716
75%	0.692	14.219
Max	25.955	71.451
Standard deviation	4.306	25.058
No. of events	255	255

As for the target factor, the standard deviation is 4.3 with the two highest fluctuations being -55.7 and 25.95. Although the biggest change was a negative one, it can be observed that most events had a positive surprise on the federal funds rate, as the median effect was 0.144.The characteristics of the path factor are similar. The largest decrease of the expect interest rate is bigger in absolute numbers compared to the largest increase in expected interest rates. Also, the median path factor is a positive number, indicating that there were more events that increased the expected interest rate. In order to give a visualized overview of the surprise factors in different points in time, the authors include Figure 3. It is worth noting that the target factor experiences very little fluctuation from 2010. This refers back to Figure 1, which shows that between 2010 and 2016 the effective federal funds rate was close to zero and did not change much.

In the next paragraphs the authors consider six events for target factor and five for path factor which brought along the highest surprise factors.

Figure 4. Graphical representation of target and path factors changes over time. Each vertical bar corresponds to each FED event. Surprise indexes of target and path factor are not comparable in their absolute values. Created by the authors.



4.1. Most significant events

Table 2. Dates of FED events, when the target and path factors were the largest, in absolute terms.

Date	Target factor
2008.01.22	-55.709
2008.10.07	25.955
2001.09.17	14.613
2008.09.29	-14.284
2007.08.17	-7.365
2008.04.30	-6.193

Date	Path factor
2008.09.29	-135.079
2009.09.23	-95.546
2009.06.24	-87.115
2008.09.16	71.451
2008.01.22	-69.669

The most significant target factor event took place on the 22nd January in 2008. On this date the intermeeting press release came out which stated that the target for the federal funds rate will be lowered 75 basis points to 3.5%. It was also stated that while the short term funding markets have rebounded a bit, the outlook on the economy is still weak as households and businesses struggle to find financing. The discount rate was also decreased from 4.75% to 4% (Federal Reserve, 2008a). The next most surprising event for the markets took place on the 7th of October in 2008 when the FOMC minutes came out which regarded the meeting they had on the 16th of September. Perhaps the more important event on that day was the speech by Chairman Ben Bernanke who addressed the problems that the FED will face and stressed the gravity of the situation (Federal Reserve, 2008b). The third event comes from the 17th of September, 2001. As 9/11 took place only six days before, it is reasonable to assume that the following days in financial markets were volatile for numerous reasons and the FED's policy was not the only significant factor. The next two most surprising events for the markets were both intermeeting press-releases. On the 29th of September 2008 the FED called a meeting where they announced that they are going to provide extra liquidity to the market (Federal Reserve, 2008c). On the 17th of August 2007 the FED expressed their concerns about the economy, but did not take any action (Federal Reserve, 2007). On the 30th of April 2008, the sixth most surprising event, the FED cut the federal funds rate to 2% and promised to act if economic situations get worse (Federal Reserve, 2008d). All in all there is no obvious common characteristic among these six events. It could be said the actions of the FED were either on a large scale or the language that they used indicated their serious concern about the economy.

Now the authors consider five of the most surprising events regarding the path factor. Again, from first sight it seems that the events are more volatile but due to the methodology

target and path surprise factors cannot be compared one to one. Two events coincide for path and target factor. The event with the highest surprise factor was on the 29th of September 2008 when extra liquidity was provided for the market. The next one happened on the 23rd of September 2009 when the FED noted that there are improvements in the economy but the fed funds rate will be held at a low level for a long time and open market operations will be continued at a significant scale (Federal Reserve, 2009a). The event on the 24th of June 2009 had a very similar message (Federal Reserve, 2009b). Both press releases noted that low interest rates may stay here for a long time. A similar message was also given on the 16th of September 2008 as the FED noted that significant monetary policy tools will be used to help the economy rebound (Federal Reserve, 2008e). The fifth most surprising event was the one that was first for the target factor. Then the FED decided to cut the fed funds rate and the discount rate then. Altogether we are left with 8 most surprising evets for path and target factor combined, as two of the events coincide and 17th of September 2001 was removed due to lack of available data to perform an event study.

5. Results

In the following paragraphs the authors will describe the results of the event studies and the regression results which show how CEE financial markets reacted to changes in surprise factors. In event studies the authors considered the events with the highest surprise factors. The event study and regression analysis was performed on each asset class (stock markets, short-term and long-term bonds) and for each country.

5.1. Stock market reactions

The analysis of stock market reaction is divided into two parts. First, event study analysis using the most surprising FED events, followed by a time series regression analysis. More detailed results for the stock market event study are depicted in Appendix C. The result show how much CEE equity markets moved compared to their historical norms around the most surprising events.

Out of the eight events with the highest surprise factors, the one that stands out for the stock markets took place on the 7th of October, 2008. Five countries reacted significantly on that date.

On that day, the FED released its minutes and announced the creation of another liquidity program. But perhaps the most important event that day was a speech by the Chairman Ben Bernanke where he focused on the dire situation of the economy and financial markets in the world. He described that the FED has to "address a problem of historic dimensions" (Federal Reserve, 2008b). The sharpest positive 1-day reaction on that day was observed in Lithuania, where returns increased by 11%, while on the same day, 1-day stock market index returns in Hungary were -7.4%. At the same, there are two more events that are worth mentioning. The first one took place on the 16th of September, 2008, when the FED announced that it will be taking extreme measures to combat crisis. The second one took place on the 29th of September, 2008, when the FED decided to provide extra liquidity to the market (Federal Reserve, 2008c). In these two days, stock market movements are less uniform across countries, but are still noticeable. However, one should take note that all of these 3 events occurred in a one month window, which raises the questions whether CEE equity markets were reacting to overall global downwards trends rather than to the FED's decisions. The authors now present the results of the time series regression analysis.

The detailed results of the regression analysis are presented in Table 3. Before described results, one should take note that due to differences in national holidays and hence trading days, the number of observations and FED events included in the sample may differ across countries. The first observation that can be made is that equity markets, in general, reacted significantly to changes in the target factor, but most of the effect came during the post-crisis period. Six out of the eight countries studied reacted significantly to changes in the target factor after the crisis. In the pre-crisis period, only Latvia's markets reacted more significantly, while the Czech Republic's and Slovenia's markets reacted less significantly. In the post-crisis period, the Baltic countries' stock markets reacted positively to increases in the target factor. The other markets that were significantly affected during the post-crisis period, Poland, Hungary and the Czech Republic, had contrary effects. In other words, stock markets reacted in different directions to changes in the target factor.

Table 3. Regression (Equation 6) analysis results for equity markets returns. Values above indicate beta coefficients for target and path factors. Values in parenthesis show the p-value of the estimated coefficients. FED events column represents how many events were part of the estimation sample. N column shows the total number of observations. As in the case of Lithuania, all sample estimation, the interpretation of coefficient is that a 1 unit increase in the target factor, on average, was associated with 0.046% higher stock market returns

Country	Value	All sample (2000-2015)				Pre-crisis (2000-2007)				After crisis (2008-2015)			
		Target	Path	Fed events	N	Target	Path	Fed events	N	Target	Path	Fed events	N
Lithuania	Coef.	**0.0460*** **	-0.0047	215	3748	-0.0187	-0.0010	88	1774	**0.0565*** **	**-0.0074* **	127	1974
	p-value	**(0.0057)**	(0.1135)			(0.6737)	(0.8057)			**(0.0044)**	**(0.0781)**		
Latvia	Coef.	0.0178	-0.0003	215	3804	**-0.2892*** **	0.0050	88	1826	**0.0574** **	-0.0049	127	1978
	p-value	(0.4261)	(0.9455)			**(0.0001)**	(0.4352)			**(0.0141)**	(0.3259)		
Estonia	Coef.	**0.0365** **	-0.0032	214	3797	0.0090	0.0008	87	1802	**0.0433** **	-0.0061	127	1995
	p-value	**(0.0342)**	(0.2903)			(0.8458)	(0.8426)			**(0.0349)**	(0.1629)		
Poland	Coef.	**-0.0473** **	0.0011	216	3782	0.0610	-0.0001	87	1786	**-0.0610*** **	0.0022	129	1996
	p-value	**(0.0150)**	(0.7422)			(0.2860)	(0.9808)			**(0.0052)**	(0.6330)		
Hungary	Coef.	**-0.0912*** **	0.0006	218	3768	0.0121	-0.0034	87	1778	**-0.1070*** **	0.0034	131	1990
	p-value	**(0.0002)**	(0.8901)			(0.8530)	(0.5606)			**(0.0002)**	(0.5683)		
Czech Republic	Coef.	**-0.0927*** **	-0.0032	219	3787	**0.1077* **	-0.0074	87	1786	**-0.1197*** **	0.0000	132	2001
	p-value	**(0.0000)**	(0.4123)			**(0.0636)**	(0.1610)			**(0.0000)**	(0.9929)		
Slovenia	Coef.	-0.0220	-0.0032	195	3177	**-0.1323** **	0.0017	66	1188	-0.0159	-0.0051	129	1989
	p-value	(0.2099)	(0.3278)			**(0.0391)**	(0.6964)			(0.4333)	(0.2524)		
Slovakia	Coef.	-0.0082	-0.0012	230	4177	-0.0304	-0.0018	96	2089	-0.0069	-0.0009	134	2088
	p-value	(0.6533)	(0.7110)			(0.5790)	(0.7042)			(0.7312)	(0.8357)		

* - coefficient significant at 10% level of significance, ** - coefficient significant at 5% level of significance, *** - coefficient significant at 1% level of significance.

When the whole time period is considered, five countries reacted significantly to changes in the target factor, but none reacted to the path factor. As for Latvia, the markets reacted negatively in the pre-crisis period and positively in the post-crisis period to changes in the target factor, making the reaction of their stock markets insignificant over the whole time period. However, most of the effect was concentrated in the post-crisis period, when monetary policy was used on an unprecedented scale and the financial markets were quite volatile. It is hard to see a common characteristic among countries that were affected significantly.

5.2. Bond market reactions

In this section the authors are going to consider the reaction of the bond markets in the CEE markets to the policies of the FED. Short term and long term bonds are analyzed separately, but in both cases the same methods were applied. The authors describe both the reactions that bond markets had on dates with highest surprise factors and reactions they had to surprise factors on average. An important point to keep in mind is that the time period for bonds is shorter than for stocks. Only the post-crisis period will be considered due to lack of available data.

5.2.1. Short term bonds

In Appendix D, the authors present the results of event study for short-term bonds. It can be observed that aside from 7th of October 2008 there were no abnormal movements in the short-term bond markets around surprising events. However, comparison of these results is difficult as the country sample is smaller due to lack of bond data for the particular dates.

Short-term bond regression analysis results are provided in Table 4. Overall neither the target nor the path factor surprises had a significant impact on the bond prices in the countries the authors considered. Only in Poland the target factor seemed to have an effect on bond prices. Otherwise, bond prices on average did not react to statements from the Federal Reserve. The result is a bit surprising, as the FED usually operates in open market operations by buying bonds and lowering short-term interest rates in the US. That should affect foreign bond yields due to foreign bonds becoming more appealing. However, we fail to find evidence for this premise.

Table 4. Regression (Equation 6) analysis results for short-term bond yield changes. Values above indicate beta coefficients for target and path factors. Values in parenthesis show the p-value of the estimated coefficients. FED events column represents how many events were part of the estimation sample. N column shows the total number of observations. As in the case of Poland, after crisis estimation, the interpretation of coefficient is that a 1 unit increase in the target factor, on average, was associated with a decrease of 19 basis points in short-term bond yields.

Country	Value	After crisis (2008-2015)		Fed events	N
		Target	Path		
Lithuania	Coef.	1.2818	-0.0795	76	1214
	p-value	(0.8763)	(0.7524)		
Latvia	Coef.	1.5643	0.1462	68	1052
	p-value	(0.8073)	(0.4860)		
Poland	Coef.	**0.2074***	-0.0372	128	2013
	p-value	**(0.0814)**	(0.1404)		
Hungary	Coef.	0.1784	0.0026	134	2088
	p-value	(0.2629)	(0.9376)		
Czech Republic	Coef.	-0.2338	0.0088	131	2007
	p-value	(0.1311)	(0.7855)		
Slovenia	Coef.	5.6009	0.0424	75	1201
	p-value	(0.2174)	(0.7638)		
Slovakia	Coef.	0.2384	-0.0528	133	2037
	p-value	(0.2265)	(0.1977)		

* - coefficient significant at 10% level of significance, ** - coefficient significant at 5% level of significance, *** - coefficient significant at 1% level of significance.

5.2.2. Long term bonds

The results of long-term bond event analysis are reported in Appendix E. The results are similar to ones of short term bonds. Even though the sample consists of only 3 countries, returns on the 7th of October 2008 have been abnormal compared to the historic norms. For other events, we only find occasional significance without clear patterns.

Long-term bond regressions analysis results are presented in Table 5. In this case both the Czech Republic's and Slovakia's long term bond prices seemed to react significantly to changes in the target factor, but the direction of the reaction was different. In the Czech Republic's case, the bond yields decreased as the target factor increases, while for Slovakia bonds moved in the opposite direction. All in all the bond markets seem to be quite isolated from the FED's policies. This is contrary to the research that has been done is the pre-crisis period in developed European

countries, where Hausman and Wongswan (2006) found that bond prices are affected by the path factor. On the other hand, these finding are consistent with Rigobon and Sack (2002) findings which show that long-term bonds do not react to the FED's decisions.

Table 5. Regression (Equation 6) analysis results for long-term bond yield changes. Values above indicate beta coefficients for target and path factors. Values in parenthesis show the p-value of the estimated coefficients. FED events column represents how many events were part of the estimation sample. N column shows the total number of observations. As in the case of Czech Republic, after crisis estimation, the interpretation of coefficient is that a 1 unit increase in the target factor, on average, was associated with a decrease of 19 basis points in long-term bond yields.

Country	Value	After crisis (2008-2015)		Fed events	N
		Target	Path		
Lithuania	Coef.	0.2380	-0.0942	78	1270
	p-value	(0.9763)	(0.7024)		
Latvia	Coef.	2.8611	0.0392	76	1205
	p-value	(0.3582)	(0.6877)		
Poland	Coef.	0.0139	0.0016	128	2013
	p-value	(0.8912)	(0.9422)		
Hungary	Coef.	0.3822	0.0129	84	1329
	p-value	(0.8873)	(0.8805)		
Czech Republic	Coef.	**-0.1931****	0.0236	131	2007
	p-value	**(0.0185)**	(0.1697)		
Slovenia	Coef.	-2.8023	-0.1051	75	1201
	p-value	(0.6527)	(0.5874)		
Slovakia	Coef.	**0.4478*****	**-0.0465***	133	2037
	p-value	**(0.0006)**	**(0.0867)**		

* - coefficient significant at 10% level of significance, ** - coefficient significant at 5% level of significance, *** - coefficient significant at 1% level of significance.

6. Discussion of results

The results show that in CEE, equity markets react to the FED's decisions and especially to those that have a higher target surprise factor. As the target factor is related to the current federal funds rate, this would imply, that stock markets are more concerned about the current rates, rather that the rates that will be prevailing in the future. Most of the stock market reaction comes from the post-crisis period, when monetary policy was very aggressive and three waves of QE were launched. Given that the direction of relationship between target factor and stock markets

is different across countries, it makes it difficult to make broad conclusions, apart from that reaction to target factor was statistically significant.

At the same time, the bond markets, on average, do not react in either case. These results are consistent with the findings of Rigobon and Sack (2002) who found that while equity markets react to decisions by the FED, long term interest rates do not. In this study the authors can add that in the CEE area, short term bonds do not react either. Following the findings of Kishor and Marfatia (2012), where it was shown that reactions to FED events are in the opposite direction before and after the crisis. While this applies for Latvia, it doesn't for other countries in the sample. This study shows that there is a difference in significance as well in the pre- and post-crisis period. Again, one outlier is Latvia where the reactions were more significant in the pre-crisis period.

7. Limitations

There are some limitations to the study as well. First of all, when the authors choose 1-day, 3-day and 5-day windows for the event study period, there is a risk that other news or information will affect the results during those time windows. As a result the authors cannot argue for causality with full conviction. Second, as the data for bond prices is rather limited, it is difficult to assess whether or not the QE rounds or the fed funds rate changes had an effect on CEE bond markets.

Also, it is possible that there are considerable co-movements in the markets which could potentially affect the study. If the Latvian markets react to European wide effects, it becomes difficult to argue over the direction of causality. A further issue with causality is that if, for example, the FED made decisions due to major turbulences in the markets, the reason for abnormal movements in CEE financial markets would be due to turbulences and not the FED's decision.

Finally, when it comes to time series regression analysis, additional control variables could have helped in crystalizing the relationship between surprise factors and returns. Variables, such as exchange rate flexibility, size of financial markets have been shown to have an impact. However, since these considerations are outside the scope of this research, they were not included.

8. Conclusions

The effects of the FED's monetary policy have been thoroughly researched in the US (Bernanke and Kuttner (2004), Rogobon and Sack (2002)) and in most other developed countries (Neely (2015), Glick and Leduct (2012)). This paper analyzed whether financial markets in the CEE region react to policy decisions by the FED. To guide this research, the authors set out to answer the research question: *Do CEE financial markets react to the FED's monetary policy decisions?*

To answer the question, the authors divided the FED's policy decisions into two categories, those that would affect current interest rates and others that are related to future monetary policy. The findings were that financial markets in the CEE only reacted to changes in the current interest rates. More accurately, only stock markets react to these changes. The authors also divided the sample time period into two parts, pre- and post-crisis. The findings were that during the post-crisis period, stock markets reacted more significantly. That might be due to the aggressive actions that the FED took in response to the Great Recession. Over the whole sample period, five countries out of eight reacted significantly to changes in current interest rates. It is worth noting that the way financial markets reacted in the CEE was not uniform. From the countries that reacted significantly, the Baltic stock markets increased as current interest rates were increased, while the reaction in other countries was the opposite. This may be due to the adoption of the euro, but it is not a conclusion that can be made with full conviction. Changes in expectations about future interest rates did not affect stock prices. Also, both long and short term bond prices were almost entirely insulated from decisions by the FED.

To the authors' mind, these results are important for both policymakers and investors in CEE markets. For central bankers it is important that communication with the FED is established and maintained so that domestic central banks could react quickly and accordingly to the FED's policies. For investors these results provide support that domestic stock market performance is not only determined by idiosyncratic domestic effects, but also by foreign effects, such as the FED's monetary policy shocks.

As this paper sought to find whether there is a reaction in CEE financial markets to FED events, further research could focus on the reasons why the CEE markets react as they do. There are multiple channels through which the reaction could take place, for example exchange rates, expected economic growth and expected interest rates in Europe. Hausman and Wongswan

(2006) show that markets that are integrated with the US, have exchange rates which are not flexible and financial markets that are developed, react to the FED's decisions more.

9. References

Ahmed, S., Zlate, A. (2014). Capital flows to emerging market economies: A brave new world? Journal of International Money and Finance, Vol. 48, pp. 221-248.

Akhtar, M. A. (1997). Understanding Open Market Operations. Public Information Department, Federal Reserve Bank of New York. Retrieved from https://research.stlouisfed.org/aggreg/meeks.pdf

Bauer, M. D., Neely, C. J. (2014). International channels of the Fed's unconventional monetary policy. Journal of International Money and Finance, Vol. 44, pp. 24-46.

Berge, T. J., Cao, G. (2014). Global Effects of U.S. Monetary Policy: Is Unconventional Policy Different? Federal Reserve Bank of Kansas City, Economic Review. Vol. 99, no. 1, pp. 65-91.

Bernanke, B., Kuttner, N. K. (2004). What Explains the Stock Market's Reaction to Federal Reserve Policy? Journal of Finance, Vol. 60, No. 3, pp.1221-1257

Chen, J., Mancini-Griffoli, T., Sahay, R. (2014). Spillovers from United States Monetary Policy on Emerging Markets: Different This Time? IMF Working Papers, 14/240.

Chen, Q., Filardo, A., He, D., Zhe, F. (2015). Financial crisis, US unconventional monetary policy and international spillovers. IMF Working Papers 15/85. Retrieved from https://www.imf.org/external/pubs/ft/wp/2015/wp1585.pdf

CME Group. (n. d.). 30-Day Federal Funds Futures and Options. Retrieved from https://www.cmegroup.com/trading/interest-rates/files/IR-143_FEDFUNDSFC_lo-res_web.pdf

Doh, T., Conolly, M. (2013). Has the Effect of Monetary Policy Announcements on Asset Prices Changed? Federal Reserve Bank of Kansas City, Economic Review, Third Quarter.

Falagiarda, M., Reitz, S. (2015). Annoucements of ECB unconventional programs: Implications for the sovereign spreads of stressed euro area countries. Journal of International Money and Finance. Vol. 53, pp. 276-295

Federal Reserve. (2007). Federal Reserve Gov. Retrieved from https://www.federalreserve.gov/newsevents/press/monetary/20070817b.htm

Federal Reserve. (2008a). Retrieved from https://www.federalreserve.gov/newsevents/press/monetary/20080122b.htm

Federal Reserve. (2008b). Federal Reserve Gov. Retrieved from http://www.federalreserve.gov/newsevents/press/monetary/20080916a.htm

Federal Reserve. (2008c). Federal Reserve Gov. Retrieved from https://www.federalreserve.gov/newsevents/press/monetary/20080929a.htm

Federal Reserve. (2008d). Federal Reserve Gov. Retrieved from https://www.federalreserve.gov/newsevents/press/monetary/20080430a.htm

Federal Reserve. (2008e). Federal Reserve Gov. Retrieved from http://www.federalreserve.gov/newsevents/press/monetary/20080916a.htm

Federal Reserve. (2009a) Federal Reserve Gov. Retrieved from https://www.federalreserve.gov/newsevents/press/monetary/20090923a.htm

Federal Reserve. (2009b) Federal Reserve Gov. Retrieved from https://www.federalreserve.gov/newsevents/press/monetary/20090624a.htm

Gagnon, J., Raskin, M., Remache, J., Sack, B. (2011). Large-Scale Asset Purchases by the Federal Reserve: Did They Work? Federal Reserve Bank of New York Economic Policy Review, 41-59.

Glick R., Leduc, S. (2012). Central bank announcements of asset purchases and the impact on global financial and commodity markets. Journal of International Money and Finance. Vol. 31, No. 8, pp. 2078-2101

Gürkaynak, R., S., Sack, B., Swanson, E. T. (2005). Do Actions Speak Louder Than Words? The Response of Asset Prices to Monetary Policy Actions and Statements. International Journal of Central Banking. Vol. 1, pp. 55-93.

Hausman, J. Wongswan, J. (2006). Global Asset Prices and FOMC Announcements. Board of the Federal Reserve System. International Finance Discussion Papers. Volume 288.

Hayo, B., Neuenkirch, M. (2010). Bank of Canada Communication, Media Coverage, and Financial Market Reactions. Economics Letters, 115(3), pp. 369-372.

Joyce, M., A. Lasaosa, I. Stevens and M. Tong. (2011). The Financial Market Impact of Quantitative Easing in the United Kingdom. International Journal of Central Banking. Vol. 7, pp. 113-161.

Kang, H., Suh, H. (2015). Reverse spillover: Evidence during emerging market financial turmoil in 2013-2014. Journal of International Financial Markets, Institutions and Money, Vol. 38, pp. 97-115.

Kishor, K,, N. Marfatia, H.A. (2012). The time-varying response of foreign stock markets to U.S monetary policy surprise: Evidence from the Federal funds futures market. Journal of International Financial Markets, Institutions & Money, Vol. 24, pp. 1-24.

Krishnamurthy, A., Vissing-Jorgensen, A. (2011). The Effects of Quantitative Easing on Interest Rates: Channels and Implications for Policy. Brooking Papers on Economic Activity (Fall), pp. 215-265.

Labonte, M. (2016). Monetary Policy and the Federal Reserve: Current Policy and Conditions. Congressional Research Service. Retrieved from https://www.fas.org/sgp/crs/misc/RL30354.pdf

Labuszewski, J. W. (2013). Understanding Eurodollar Futures. Retrieved from: https://www.cmegroup.com/trading/interest-rates/files/understanding-eurodollar-futures.pdf

Modigliani, F., Sutch, R. (1966). Innovations in Interest Rate Policy. The American Economic Review. Vol. 56, No. 1/2 , pp. 178-197

Neely, C. J. (2015). Unconventional monetary policy had large international effects. Journal of Banking & Finance. Vol. 52, pp. 101-111.

OECD (2001). Central and Eastern European Countries. Glossary of Statistical Terms. Retrieved from https://stats.oecd.org/glossary/detail.asp?ID=303

Rigobon, R., & Sack, B. (2002). The Impact of Monetary Policy on Asset Prices. Retrieved from http://www.federalreserve.gov/pubs/feds/2002/200204/200204pap.pdf

Roche, Cullen O. (2014). Understanding Quantitative Easing. Retrieved from http://dx.doi.org/10.2139/ssrn.2397992

Villanueva, M. (2015). Quantitative Easing and US Stock Prices. Retrieved from http://dx.doi.org/10.2139/ssrn.2656329

Wrights, J.H. (2011). "What Does Monetary Policy Do to Long-Term Interest Rates at the Zero Lower Bound?" Economic Journal 122(564), pp. 447-446.

10. Appendices

Appendix A. Estimation of scaling coefficients.

As mentioned in section 3.1, after principal component analysis is performed and first two principal components are taken, denoted F_1 and F_2, the factors are rotated and rescaled such that the first component is only correlated with the federal funds futures of the current month ($mp_{1,t}$), while the second component is correlated with remaining securities. Mathematically, this mean that principal component matrix F is transformed into matrix Z, using scaling and rotating coefficients in matrix U. In this section, the authors describe how these coefficients are obtained. The method that is followed in this study is based on (Gürkaynak, et al. 2005).

$$Z = FU \tag{3}$$

$$U = \begin{bmatrix} \alpha_1 & \beta_1 \\ \alpha_2 & \beta_2 \end{bmatrix} \tag{4}$$

In order to estimate scaling coefficients in matrix U, we need to construct 4 sets of equations, which would allow to solve for 4 unknowns. The first two equations come from the fact that the matrix U columns are normalized to have unit length. This makes the new two factors Z_1 and Z_2 have unit variance. In practice, this means that

$$\alpha_1{}^2 + \alpha_2{}^2 = 1$$

(7)

$$\beta_1{}^2 + \beta_2{}^2 = 1$$

(8)

Second, the new two factors Z_1 and Z_2 should remain uncorrelated and orthogonal. Hence we arrive to the third restriction

$$E(Z_1 Z_2) = \alpha_1\beta_1 + \alpha_2\beta_2 = 0$$

(9)

For the final restriction, we denote $\gamma_1$as the known factor loading of mp_1on F_1 and γ_2 as the known factor loading of mp_1on F_2. Since

$$F_1 = \frac{1}{\alpha_1\beta_2 - \alpha_2\beta_1}[\beta_2 Z_1 - \alpha_2 Z_2] \tag{10}$$

$$F_2 = \frac{1}{\alpha_1\beta_2 - \alpha_2\beta_1}[\alpha_1 Z_2 - \beta_1 Z_1] \tag{11}$$

This implies that:

$$\gamma_2\alpha_1 - \gamma_1\alpha_2 = 0$$

(12)

Using equations 7, 8, 9, and 12 to impose restrictions on scaling coefficients, we can then fully identify matrix *U*. Using matrix *U*, we estimate matrix *Z*, which contains target factor, denoted Z_1 and path factor, denoted Z_2. In this case target factor only correlated with mp_1, while path factor correlated with remaining securities

Appendix B. Data sources

Data	Period	Source	Comments
Equity market performance	2000.01.01-2015.12.18	Thomson Reuters Datastream	Market indices for sample countries: Latvia (RIGSE), Lithuania (VILSE), Estonia (TALSE), Poland (WIG), Hungary(BUX), Czech Republic (PX), Slovenia (SBITOP), Slovakia (SKSM)
Short-term government bonds	2006.01.01-2016.01.01	Thomson Reuters Datastream	Short-term government bonds yields were taken from Thomson Reuters Zero Coupon 1-Y daily bond yields. Coverage varied across countries
Long-term government bonds	2006.01.01-2016.01.01	Thomson Reuters Datastream	Long-term government bonds were taken from Thomson Reuters Zero Coupon 10-Y daily bond yields. Coverage varied across countries
Federal Funds Futures	1997 Jan - 2016 Jan	Thomson Reuters Datastream	Futures contracts used to calculate surprise factors of FED events. One futures contract was retrieved for each calendar month
Eurodollar Futures	1997 Q1 - 2018 Q3	Thomson Reuters Datastream	Futures contracts used to calculate surprise factors of FED events. One futures contract was retrieved for each quarter.

Table B.1. List of data sources used for the study. Data from Thomson Reuters Datastream was retrieved on March 1st, 2016.

Appendix C. Stock market results and returns on the dates with most surprising events

Table C.1. Event study results of equity market performance during the most surprising FED events in the sample period. Historical distribution was estimated from 2006.07.01 to 2011.07.01. Values above indicate the daily return on event day (0.01 = 1%). Values in parenthesis show the percentage of returns that were lower than the observed return.

Country	Lithuania			Latvia			Estonia			Poland		
Period	1-day	3-day	5-day	1-day	3-day	5-day	1-day	3-day	5-day	1-day	3-day	5-day
2007.08.17	-0.005	0.007	0.004	0.009	0.008	0.014	-	-	-	-0.013	**0.043***	**0.057***
	(0.25)	(0.63)	(0.54)	(0.80)	(0.69)	(0.72)				(0.15)	**(0.95)**	**(0.96)**
2008.01.22	0.010	0.012	0.018	-0.002	0.006	-0.006	-0.007	-0.019	-0.009	0.041**	0.028	0.066**
	(0.85)	(0.74)	(0.76)	(0.43)	(0.63)	(0.36)	(0.25)	(0.17)	(0.37)	(0.99)	(0.88)	(0.98)
2008.04.30	-0.004	-0.012	-0.020	0.007	0.016	0.023	0.000	0.000	0.019	0.016	0.033	0.019
	(0.32)	(0.23)	(0.20)	(0.75)	(0.81)	(0.84)	(0.50)	(0.49)	(0.74)	(0.89)	(0.92)	(0.73)
2008.09.16	**-0.037****	-0.018	**-0.088***	**-0.038****	0.001	-0.018	**-0.052****	-0.001	-0.030	0.004	**0.049***	0.029
	(0.02)	(0.16)	**(0.03)**	**(0.02)**	(0.51)	(0.22)	**(0.01)**	(0.46)	(0.15)	(0.62)	**(0.97)**	(0.82)
2008.09.29	**0.023***	-0.012	**-0.187*****	0.019	-0.013	**-0.144*****	0.011	-0.041	**-0.120****	0.011	-0.014	**-0.090****
	(0.97)	(0.23)	**(0.00)**	(0.92)	(0.22)	**(0.00)**	(0.85)	(0.06)	**(0.01)**	(0.81)	(0.24)	**(0.02)**
2008.10.07	**0.110*****	**0.121*****	**0.148*****	**0.092*****	**0.095*****	**0.124*****	**0.057*****	0.024	0.024	0.002	**-0.064****	**-0.082****
	(1.00)	**(1.00)**	**(1.00)**	**(1.00)**	**(1.00)**	**(1.00)**	**(1.00)**	(0.87)	(0.80)	(0.57)	**(0.02)**	**(0.02)**
2009.06.24	0.003	0.001	-0.002	-0.017	-0.006	0.024	-0.003	0.003	0.004	0.005	0.011	0.005
	(0.61)	(0.50)	(0.42)	(0.12)	(0.37)	(0.85)	(0.38)	(0.54)	(0.55)	(0.66)	(0.67)	(0.54)
2009.09.23	**-0.024***	-0.043	-0.044	**-0.046****	**-0.119*****	**-0.153*****	-0.013	-0.020	-0.025	-0.004	-0.016	-0.004
	(0.04)	(0.05)	(0.08)	**(0.01)**	**(0.00)**	**(0.00)**	(0.12)	(0.17)	(0.18)	(0.36)	(0.22)	(0.39)

* - return percentile smaller than 5% or larger than 95%, ** - return percentile smaller than 2.5% or larger than 97.5%, *** - return percentile smaller than 0.5% or larger than 99.5%.

Table C.1 (continued). Event study results of equity market performance during the most surprising FED events in the sample period. Historical distribution was estimated from 2006.07.01 to 2011.07.01. Values above indicate the daily return on event day. Values in parenthesis show the percentage of returns that were lower than the observed return.

Country	Czech Republic			Hungary			Slovenia			Slovakia		
Period	1-day	3-day	5-day	1-day	3-day	5-day	1-day	3-day	5-day	1-day	3-day	5-day
2007.08.17	0.004	0.034	**0.056***	-	-	-	0.014	0.016	0.031	0.006	0.016	0.031
	(0.61)	(0.93)	**(0.96)**				(0.92)	(0.80)	(0.89)	(0.87)	(0.80)	(0.89)
2008.01.22	**0.081*****	**0.057***	**0.079****	**0.033***	0.031	0.029	**0.026****	0.024	0.034	0.000	0.024	0.034
	(1.00)	**(0.97)**	**(0.98)**	**(0.96)**	(0.87)	(0.81)	**(0.98)**	(0.90)	(0.91)	(0.61)	(0.90)	(0.91)
2008.04.30	**0.031***	0.021	0.017	0.013	0.026	0.024	0.015	**0.054****	0.033	0.000	**0.054****	0.033
	(0.97)	(0.84)	(0.72)	(0.82)	(0.85)	(0.76)	(0.92)	**(0.99)**	(0.90)	(0.61)	**(0.99)**	(0.90)
2008.09.16	-0.008	**0.098****	**0.077****	-0.024	**0.053***	0.038	**-0.038****	**0.063****	0.042	**-0.022***	**0.063****	0.042
	(0.24)	**(0.99)**	**(0.98)**	(0.07)	**(0.96)**	(0.87)	**(0.01)**	**(0.99)**	(0.95)	**(0.04)**	**(0.99)**	(0.95)
2008.09.29	**0.025***	0.000	**-0.105****	0.016	0.011	**-0.079***	0.015	-0.003	**-0.080****	-0.000	-0.003	**-0.080****
	(0.96)	(0.48)	**(0.02)**	(0.86)	(0.66)	**(0.03)**	(0.92)	(0.45)	**(0.02)**	(0.28)	(0.45)	**(0.02)**
2008.10.07	0.002	**-0.060***	-0.043	**-0.074****	-0.049	**-0.110****	**0.042****	0.028	**0.094*****	0.000	0.028	**0.094*****
	(0.56)	**(0.04)**	(0.10)	**(0.01)**	(0.06)	**(0.02)**	**(0.99)**	(0.93)	**(1.00)**	(0.61)	(0.93)	**(1.00)**
2009.06.24	0.002	0.006	-0.007	0.013	0.007	-0.007	-	-	-	-	-	-
	(0.56)	(0.59)	(0.35)	(0.82)	(0.61)	(0.39)						
2009.09.23	-0.015	-0.002	-0.038	-0.023	-0.023	-0.023	-0.002	-0.002	0.014	0.000	-0.002	0.014
	(0.13)	(0.43)	(0.11)	(0.08)	(0.18)	(0.23)	(0.42)	(0.46)	(0.72)	(0.61)	(0.46)	(0.72)

* - return percentile smaller than 5% or larger than 95%, ** - return percentile smaller than 2.5% or larger than 97.5%, *** - return percentile smaller than 0.5% or larger than 99.5%.

Appendix D. Short term bonds results and returns on dates with the biggest surprise factor

Table D.1. Event study results of short-term (10Y) bond performance during the most surprising FED events in the sample period. Historical distribution was estimated from 2006.07.01 to 2011.07.01. Values above indicate the daily change in bond yields on event day (0.01 = 1 basis point). Values in parenthesis show the percentage of returns that were lower than the observed return.

Country	Poland			Czech Republic			Slovakia			Hungary		
Period	1-day	3-day	5-day	1-day	3-day	5-day	1-day	3-day	5-day	1-day	3-day	5-day
2007.08.17	0.090	0.033	0.098	-0.003	0.016	-0.005	0.006	0.002	-0.000	0.020	0.070	0.050
	(0.94)	(0.69)	(0.86)	(0.49)	(0.57)	(0.48)	(0.61)	(0.54)	(0.55)	(0.75)	(0.82)	(0.73)
2008.01.22	0.013	0.036	0.121	0.138	-0.050	-0.041	0.116	0.152	-0.000	-0.010	-0.060	-0.100
	(0.62)	(0.70)	(0.90)	(0.91)	(0.30)	(0.37)	(0.89)	(0.91)	(0.55)	(0.37)	(0.27)	(0.26)
2008.04.30	-0.015	0.008	0.015	-0.032	-0.041	-0.091	0.005	0.012	0.038	0.000	-0.080	-0.150
	(0.36)	(0.55)	(0.55)	(0.32)	(0.32)	(0.23)	(0.60)	(0.60)	(0.70)	(0.69)	(0.23)	(0.16)
2008.09.16	-0.036	0.026	-0.030	0.013	0.126	0.094	0.006	0.105	0.087	0.070	-0.030	0.090
	(0.20)	(0.66)	(0.34)	(0.61)	(0.89)	(0.80)	(0.61)	(0.85)	(0.81)	(0.91)	(0.42)	(0.79)
2008.09.29	-0.082	-0.101	-0.144	-0.044	-0.077	-0.056	0.059	-0.180	**-0.448****	0.030	0.100	0.120
	(0.07)	(0.09)	(0.08)	(0.28)	(0.23)	(0.32)	(0.80)	(0.09)	**(0.01)**	(0.78)	(0.86)	(0.82)
2008.10.07	**0.202****	**0.192***	**0.309****	-0.145	0.111	0.018	**0.558****	0.200	**0.442****	**0.270****	**0.270***	0.270
	(0.99)	**(0.97)**	**(0.98)**	(0.07)	(0.87)	(0.56)	**(0.99)**	(0.94)	**(0.98)**	**(0.98)**	**(0.95)**	(0.93)
2009.06.24	0.006	0.050	-0.007	0.050	0.054	0.038	0.094	0.078	0.005	-0.080	-0.120	-0.150
	(0.54)	(0.77)	(0.45)	(0.75)	(0.71)	(0.64)	(0.86)	(0.80)	(0.58)	(0.11)	(0.13)	(0.15)
2009.09.23	-0.029	0.007	-0.004	-0.034	-0.038	0.047	-0.178	-0.063	**-0.382****	0.000	-0.050	-0.080
	(0.24)	(0.54)	(0.46)	(0.31)	(0.34)	(0.67)	(0.06)	(0.26)	**(0.02)**	(0.69)	(0.32)	(0.29)

* - change in bond yield percentile smaller than 5% or larger than 95%, ** - change in bond yield percentile smaller than 2.5% or larger than 97.5%, *** - change in bond yield percentile smaller than 0.5% or larger than 99.5%.

Appendix E. Long term bonds results and returns on events with the highest surprise factor

Table E.1. Event study results of long-term (10Y) bond performance during the most surprising FED events in the sample period. Historical distribution was estimated from 2006.07.01 to 2011.07.01. Values above indicate the daily change in bond yields on event day (0.01 = 1 basis point). Values in parenthesis show the percentage of returns that were lower than the observed return.

Country	Czech Republic			Poland			Slovakia		
Period	1-day	3-day	5-day	1-day	3-day	5-day	1-day	3-day	5-day
2007.08.17	0.011	-0.029	0.007	-0.038	0.035	0.037	-0.039	-0.022	-0.002
	(0.64)	(0.31)	(0.54)	(0.16)	(0.73)	(0.67)	(0.22)	(0.37)	(0.49)
2008.01.22	0.042	-0.037	-0.011	0.051	-0.020	0.045	**-0.209****	-0.032	-0.118
	(0.88)	(0.27)	(0.44)	(0.89)	(0.37)	(0.71)	**(0.01)**	(0.32)	(0.11)
2008.04.30	-0.030	0.013	0.030	0.036	-0.061	-0.139	0.098	0.086	0.041
	(0.17)	(0.58)	(0.66)	(0.83)	(0.19)	(0.11)	(0.93)	(0.87)	(0.68)
2008.09.16	-0.045	-0.055	-0.053	0.022	0.117	0.136	0.053	0.146	0.075
	(0.11)	(0.18)	(0.22)	(0.74)	(0.94)	(0.91)	(0.83)	(0.95)	(0.80)
2008.09.29	-0.044	-0.030	0.052	-0.021	**-0.180****	**-0.252****	0.020	-0.005	-0.055
	(0.11)	(0.30)	(0.74)	(0.29)	**(0.02)**	**(0.02)**	(0.65)	(0.46)	(0.25)
2008.10.07	**0.086***	**0.158***	0.332**	**-0.176*****	0.068	0.123	**0.160****	**0.193***	**0.261****
	(0.97)	**(0.97)**	(0.99)	**(0.00)**	(0.83)	(0.90)	**(0.98)**	**(0.97)**	**(0.98)**
2009.06.24	**-0.084***	**-0.139***	-0.182	-0.008	-0.009	-0.057	**0.203****	0.091	0.018
	(0.04)	**(0.05)**	(0.05)	(0.42)	(0.44)	(0.27)	**(0.99)**	(0.88)	(0.58)
2009.09.23	-0.014	0.017	0.040	**-0.083***	-0.075	-0.131	-0.039	-0.089	**-0.180***
	(0.31)	(0.61)	(0.69)	**(0.04)**	(0.15)	(0.12)	(0.22)	(0.14)	**(0.05)**

* - change in bond yield percentile smaller than 5% or larger than 95%, ** - change in bond yield percentile smaller than 2.5% or larger than 97.5%, *** - change in bond yield percentile smaller than 0.5% or larger than 99.5%.