Day of the week effect in central European stock markets

Stavarek, Daniel and Heryan, Tomas

Silesian University - School of Business Administration

28 April 2012

Day of the Week Effect in Central European Stock Markets

Daniel Stavárek, Tomáš Heryán

Silesian University in Opava
School of Business Administration in Karviná
Department of Finance
Univerzitní nám. 1934/3
733 40 Karviná
Czech Republic

E-mail: stavarek@opf.slu.cz
E-mail: heryan@opf.slu.cz

Abstract

The aim of the paper is to estimate the day of the week effect in the stock markets in the Czech Republic, Hungary and Poland over the period 2006 – 2012. The entire period of estimation is divided to six sub-periods capturing individual phases of the financial and economic crisis. We separately estimate a modified GARCH-M (1,1) model for each country and each sub-period using daily returns of the major national stock market indices. The day of the week effect is measured for both daily returns and conditional variance (volatility) of the returns. The results clearly indicate that there is a little evidence of day of the week effect. Daily calendar anomalies are rather sporadic, isolated, unstable over time and often opposite to theoretical assumptions. There is no phase of financial crisis characteristic of significantly increased incidence of day of the week effects. We conclude that the day of the week effect is not typical for the Central European stock markets and the recent financial crisis seems to have no impact on existence of this phenomenon in the markets.

Key words: day-of-the-week effect, calendar anomalies, stock market, GARCH-M model, financial crisis

JEL codes: C32, G10

Research behind this paper was supported by the Student Grant Competition of Silesian University within the project SGS/25/2010 'Financial integration in the EU and its effect on corporate sector'.

1. Introduction

Some decades ago, the Efficient market hypothesis (hereafter EMH) remarkably influenced financial theory and practice. The main contribution to the theory is often attributed to Fama's survey study [6] where the efficient capital markets were promoted. In efficient markets, asset prices reflect the best estimation of market participant regarding the expected risk and return of the assets while the information currently known about the asset is taken into account. Hence, all assets in the market will be appropriately priced offering adequate level of expected return to risk. In particular, it is stated in [6] that EMH can be distinguished in three versions depending on the nature of the information subset of interest: (i) strong form, (ii) semi-strong form, (iii) weak form. The weak form claims that asset prices already correspond with all past publicly available information. The semi-strong form states both that prices reflect all publicly available information and that prices instantly change to reflect new public information. The strong form additionally claims that prices instantly reflect even hidden or 'insider' information.

However, many studies found empirical evidence against validity of the semi-strong and weak forms of EMH. As it is pointed out in [14] or [16], many financial economists and statisticians began to believe that stock prices are at least partially predictable. Such contradictions in asset pricing are considered as anomalies. If the anomalies appear regularly in trading with stocks and can influence stock market returns they are usually referred to calendar anomalies. Calendar anomalies rest on the basic assumption that the past behaviour of a stock's price is rich in information pertaining to its future behaviour. In other words, the study of calendar anomalies suggests that investors could use these results on anomalies to predict stock market movements on given days [13].

The most important examples of calendar anomalies in stock markets are day of the week effect, twist of the Monday, turn of the month, turn of the year and holiday periods. The present paper is focused solely on day of the week effect (hereafter DWE). We can distinguish several approaches to the effect in literature. The original understanding of DWE was formulated in [5] as evidence of large stock market decrease between the Friday close and the Monday close. By contrast, it is suggested in [7] that returns on Monday are lower than those for Tuesday through Friday. Finally, DWE according to [12] is simply that weekdays differ in their returns.

The Central European (hereafter CE) countries have made significant progress towards integration with the world economy over the past 15 years. Although the CE stock markets are inevitably involved in the process of convergence and integration they have a brief history compared to mature markets in Europe and the United States. Likewise, as compared to other international markets, the liquidity of the CE markets is lower, and their size relatively small [18]. According to the World Federation of Exchanges, the CE stock markets represented 0.5% of the world stock market capitalization in 2010.

We focus on stock markets in the Czech Republic, Hungary and Poland. Data from the World Bank suggest that the market capitalization as a percentage of GDP decreased during the period 2006 – 2010 from 34.1% to 22.4% in the Czech Republic, from 37.2% to 21.2% in Hungary, and from 43.6% to 40.6% in Poland. Despite this unfavourable development these markets are the largest, most liquid and most integrated in the CE region. It is reported in [10] that the three analysed CE markets have strong presence of foreign institutional investors and large volumes traded by foreign investors. Furthermore, spillovers as well as macroeconomic announcements from developed markets do impact the three CE markets under investigation. Therefore, we believe that these markets are the best candidates for analysis of stock market calendar anomalies in the CE region.

The aim of the paper is to estimate DWE in the stock markets in the Czech Republic, Hungary and Poland over the period of six years (April 2006 – March 2012). The present paper substantially contributes to the existing literature as it covers the most recent period and the markets that have not been in the centre of researchers' interest. Since the analysed period includes the global financial crisis the paper also reveals the influence of the financial crisis and its phases on presence and character of DWE.

The paper is structured as follows. In Section 2, we review the relevant literature. In Section 3, we introduce and describe the dataset and specify the model used in estimation. In Section 4, we present and discuss the results obtained from estimations. Section 5 concludes the paper with summary of crucial findings.

2. Review of relevant literature

The empirical literature is rich on studies that examine DWE and other calendar anomalies in matured and developed stock markets as well as emerging markets in Asia or Latin America. However, we are aware of only few studies that address DWE in the CE stock markets. Some of these papers, in addition, do not focus strictly on the CE region but incorporate the CE markets to a larger group of analysed markets. Various techniques and approaches were applied by researchers with no general consensus on the best method to be used for DWE estimation. All studies geographically relevant to the present paper are listed and summarized in Tab. 1.

The first serious attempt to investigate DWE in the CE emerging stock markets is [15]. They study DWE in eight stock markets during the period 22 September 1997 – 29 March 2002 and come to the following conclusions. Monday returns were negative and significant for the Czech and Romanian stock markets. Wednesday returns were significantly positive for the Slovenian market. The DWE was not revealed in the Polish and Slovak stock markets.

The study [1] focuses on even larger group of 11 emerging stock markets in Central and Eastern Europe. The authors use data on stock market indices from inception of each market's major index to 6 September 2002. They test the classical hypothesis that stock returns are significantly lower or negative on Mondays relative to other weekdays. Their results indicate negative Monday returns in six markets but only returns in Estonia and Lithuania are significantly negative. After application of supplementary tests the authors conclude that no evidence of DWE in form of Monday anomaly was found.

In [19], various calendar anomalies in the Czech Republic, Slovakia and Slovenia are examined. The results are also rather sceptical on existence of DWE and other effects. They find only very weak evidence of the January effect, DWE, and the turn of the month effect. Moreover, the effects have different characteristics based on the differences in the stock markets. As regards to DWE, they only revealed a weak existence in mean return for Slovenia, but in opposite direction than theory suggests.

Tab. 1: Summary of relevant literature

Paper	Method	Stock markets analyzed	Period
Patev et al. (2003)	OLS regression, GARCH–M	Romania, Hungary, Latvia, Czech Republic, Russia, Slovakia, Slovenia, Poland	09/1997 – 03/2002
Ajayi et al. (2004)	OLS regression	Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Russia, Slovakia, Slovenia	Launch of national index – 09/2002
Tonchev and Kim (2004)	OLS regression, GARCH	Czech Republic, Slovakia, Slovenia	01/1999 – 06/2003
Apolinario et al. (2006)	GARCH, T-GARCH	Germany, Austria, Belgium, Denmark, Spain, France, Netherlands, Portugal, United Kingdom, Czech Republic, Sweden, Switzerland	07/1999 – 03/2004
Chukwuogor-Ndu (2006)	Kruskal-Wallis test	Austria, Belgium, Czech Republic, Denmark, Germany, France, Italy, Netherlands, Russia, Slovakia, Spain, Sweden, Turkey, Switzerland, United Kingdom	01/1997 – 12/2004
Žikeš and Bubák (2006)	PAR-PGARCH	Czech Republic, Hungary, Poland, and Germany	01/1997 – 06/2004
Yalcin and Yucel (2006)	EGARCH-M	20 countries (including Czech Republic, Hungary, Poland)	Different start – 03/2005
Strawiński and Ślepaczuk (2008)	M-estimators and OLS regression	Poland	02/1998 – 30/2008
Borges (2009)	(Bootstrap) OLS Regression, GARCH, Kruskal-Wallis test	Austria, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Netherlands, Norway, Poland, Portugal, Spain, Switzerland, United Kingdom	01/1994 – 12/2007
Högholm et al. (2011)	Kruskal-Wallis one day ANOVA test	18 European countries (incl. Czech Republic, and Hungary).	01/2000 – 12/2006
Guidi et al. (2011)	GARCH-M	Bulgaria, Czech Republic, Hungary, Poland, Romania, Slovakia, Slovenia	01/1999 – 01/2009
Gajdošová et al. (2011)	OLS regression	Czech Republic, Hungary, Poland, Slovakia, Turkey	01/2005 – 11/2010

Source: Authors' elaboration

The focus of [2] is primarily on developed European markets but the paper analyses also the Czech stock market as the only example of emerging CE markets. The results obtained are in accordance with above cited studies since the Czech market as one of the two did not exhibit any evidence of DWE. The authors of [4] used a battery of parametric and non-parametric tests on daily returns of 15 European stock markets in the period 1997 – 2004. Application of the Kruskal-Wallis test provided no evidence of the day of the week effect in the Czech Republic's stock market.

By contrast, [21] focus on the same period 1997 – 2004 and investigate the seasonality and nontrading effect in stock market indices of the Czech Republic, Germany, Hungary and Poland. They used the PAR-PGARCH model and revealed significant day of the week effects in the mean of returns on the Czech and Polish index, and significant seasonality in the volatility of the Hungarian index. High frequency data from the Warsaw stock exchange is used in [17] to verify daily and hourly calendar effects. Based on estimations of robust regression models they conclude that positive DWE for Monday and persistent and positive open jump and end of session effects are present in the Polish stock market.

In [20], calendar anomalies in 20 emerging stock markets from different continents are investigated and results suggest that DWE is present in market returns for three countries and in market volatility for five countries. Only one country reports DWE in both return and variance specifications. None of the CE markets examined in the present paper showed DWE evidence at 1% significance level that is recommended by the authors for estimations with time series with thousands of daily observations.

Similarly to most of the previous studies, [3] finds no strong and convincing evidence of calendar effects across the group of analysed countries. European stock markets seem to be mostly immune to DWE. The only effect that is shared by more countries is the tendency for lower returns in the holiday months of August and September. However, all the revealed calendar anomalies are basically country-specific. Similar conclusion is presented in [11] as they point out that DWE is rather local than regional of global phenomenon. The results for CE stock markets only indicate an increase of conditional volatility on Wednesday for Hungary.

The evidence on DWE in CE and Turkey's stock markets before and during financial crisis is compared in [8]. Application of regression models with dummy variables leads to conclusion that DWE was present only in the Czech (decreasing Monday effect) and Hungarian (increasing Friday effect) stock markets during the crisis. It was impossible to find any aspect common for all CE markets in the estimation results. Results of [9] also confirm rather sporadically evidence of DWE in CE stock markets. Moreover, substantial differences among countries prevent authors from drawing any general conclusion. The only notable feature of the results is that the Monday effect in volatility (variance) tends to be present in more indices in the post accession than in the pre accession EU period.

After the review of relevant literature one can conclude that the existing studies generally found none or little evidence of DWE in the CE stock markets under examination. This conclusion prevailed regardless the methodology and econometric techniques applied. The present paper contributes to existing literature on DWE as it covers the most recent period and the markets that have not been in the centre of researchers' interest. Since the analysed period includes the global financial crisis the paper also reveals the influence of the financial crisis and its phases on presence and character of DWE. The findings can be worth to market participants for their investment decisions.

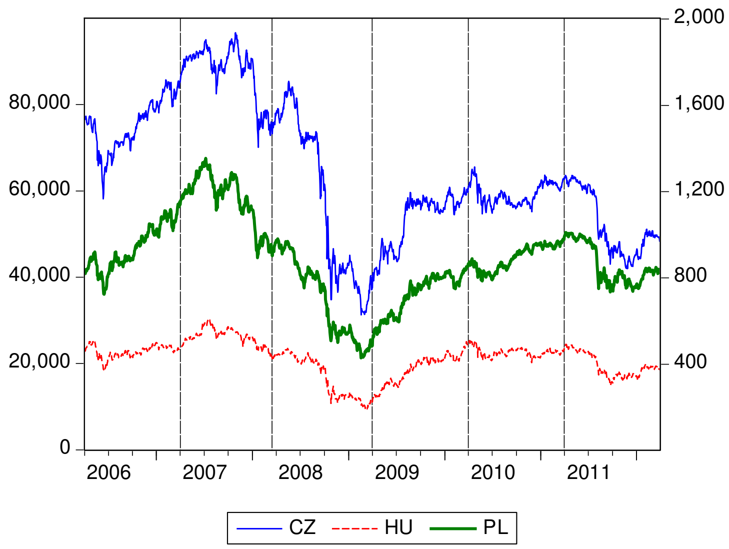
3. Overview of stock markets, data description and model specification

This paper employs the daily closing values of the stock market main indices in the Czech Republic, Hungary and Poland. Namely, we use the Prague Stock Exchange Index (PX), the Budapest Stock Exchange Index (BUX) and the Warsaw Stock Exchange Index (WIG). The time series of the indices' closing values were collected from the Patria financial database. We consistently use five observations per week and the returns for non-trading days are calculated using the closing price indices from the last trading day. This approach is followed in order to avoid possible bias from the loss of information due to public holidays.

The period under estimation starts on April 2006 and ends on March 2012. Hence, we have 1565 daily returns for each stock market in total. The whole estimation period was divided into six sub-periods to capture individual phases of the financial crisis. The pre-crisis period (Period 1) is from April 2006 to March 2007. The phase of crisis initialization (Period 2) starts in April 2007 and ends on 14 March 2008. The crisis culmination (Period 3) lasts from 17 March 2008 to end of March 2009. The phase of crisis stabilization (Period 4) covers the period from April 2009 to March 2010. The post-crisis phase (Period 5) starts in April 2011 and ends on 31 March 2011. Finally, the debt-crisis phase (Period 6) is from April 2011 to March 2012. Although the phasing of the analysed period is rather arbitrary it reflects generally accepted turning points in the timeline of the financial crisis. Although the recent sovereign-debt crisis that hit many countries in the euro area is sometimes considered as a crisis of specific kind we incorporate it to the analysis as the last phase. We believe that the financial crisis remarkably contributed to uncovering of the structural economic problems that stay behind the sovereign-debt crisis.

Fig. 1 depicts development of the stock market indices over the entire period of analysis. One can clearly observe that the main development trends are synchronized in all stock markets. Nevertheless, in spite of sharing the trends, the markets did not respond to domestic and international impulses uniformly and the overall change of stock market indices differ significantly. The only market with positive change is the Polish one (+0.97 %). The other two markets recorded substantially negative change: -36.49 % for the Czech and -18.97 % for the Hungarian stock market.

Fig. 1: Development of stock market indices



Source: Authors' calculations based on data from Patria database
Note: Czech index on the right axis, Hungary's and Poland's index on left axis.

For better understanding of the market development as well as results of DWE estimations we also provide a basic description of the analysed CE stock markets that captures the period of estimation. In Tab. 2, we present overview of market capitalization, annual turnover, number of trades and number of companies that are listed in official stock market of the exchange. Although all exchanges also offer trading with bonds, derivatives, exchange-traded funds and other securities and financial instruments but the respective figures are not reported in the paper as we focus solely on stock market. The Warsaw Stock Exchange is the leading stock market in CE region according to all parameters used in comparison. However, the Prague Stock Exchange has the highest average volume of transaction realized in the market. Hence, the Czech market seems to be used more by larger portfolio or institutional investors than small and individual investors.

Tab. 2: Elementary description of analysed stock markets

	2006	2007	2008	2009	2010
	Czech Republic – Prague Stock Exchange				
Market capitalization (EUR mln)	34,693	47,987	29,615	31,265	31,922
Turnover (EUR mln)	28,361	35,954	33,764	17,472	15,258
Trades	567,893	670,873	1,395,871	1,571,640	1,162,508
Listed companies	32	32	29	25	27
	Hungary – Budapest Stock Exchange				
Market capitalization (EUR mln)	31,687	31,528	13,326	21,093	20,624
Turnover (EUR mln)	22,525	34,403	20,916	18,957	19,925
Trades	1,464,580	1,629,278	1,893,044	3,349,838	2,612,330
Listed companies	41	41	43	46	52
	Poland – Warsaw Stock Exchange				
Market capitalization (EUR mln)	112,826	144,323	65,178	105,157	142,272
Turnover (EUR mln)	40,401	61,152	45,478	38,819	52,260
Trades	10,280,959	15,203,866	9,836,831	13,274,986	13,120,775
Listed companies	265	375	458	486	585

Source: Various issues of the European Exchange Report by the Federation of European Securities Exchanges

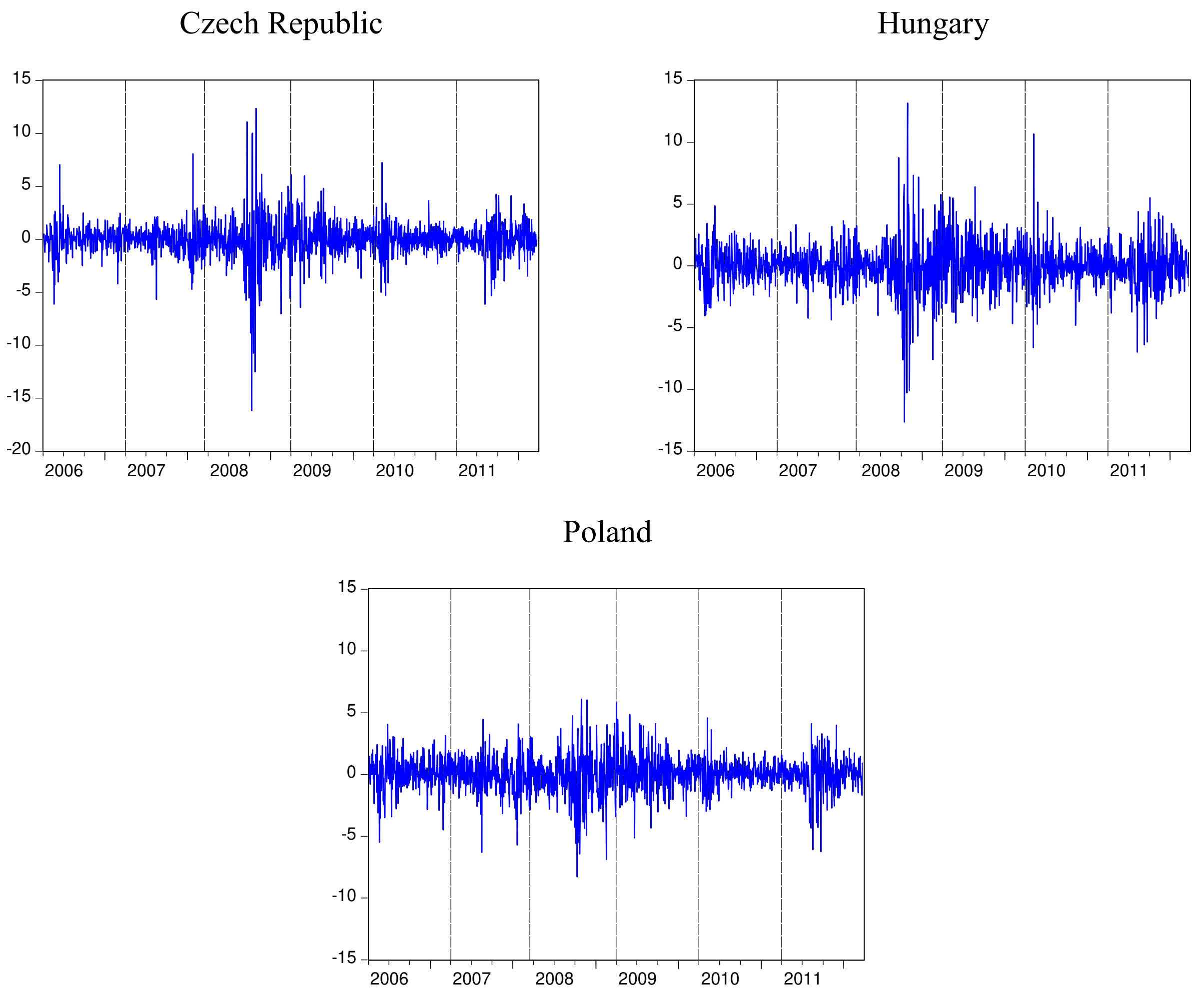
Following the standards used in literature, daily returns are calculated as first difference in natural logarithms and then multiplied by 100 to approximate percentage changes:

$$R_t = \ln\left(I_t / I_{t-1}\right) \times 100 \tag{1}$$

where *It* and *Rt* refer to the stock market index closing value and the daily return on day t, respectively. The calculated daily returns are depicted in Fig. 2. The vertical lines in graphs delimitate the six phases of the financial crisis.

Although a higher volatility and serious fluctuations of daily returns are observable in all stock markets during the phase of crisis culmination the Polish market seems to be least affected by the crisis. By contrast, one can observe many extreme daily returns considerably exceeding the usual levels in the Czech and Hungarian markets. All markets demonstrate a clear tendency to restoration of standard behaviour patterns in the course of Period 4 and Period 5. By contrast, Period 6 brought a new wave of instability into stock markets as the sovereign-debt crisis in the euro area expanded in the second half of 2011. It is evident from the graphs that the Hungary's stock market displayed the highest volatility at this time as Hungary has to face the most serious problems with sovereign and private sector debt in the group of CE economies.

Fig. 2: Stock market indices' daily returns (in %) in the financial crisis periods

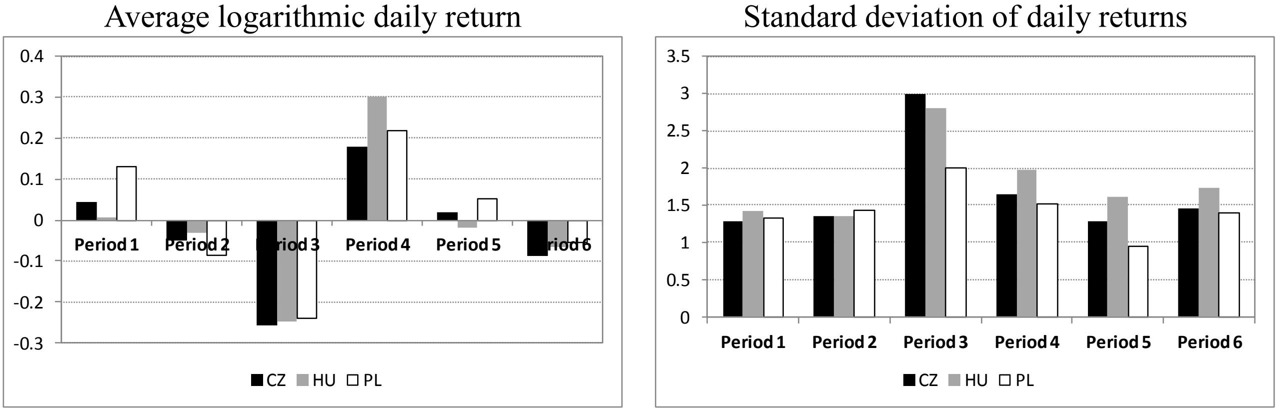


Source: Authors' calculations

The differences among the phases of financial crisis can be also documented by comparison of the average daily returns and standards deviations. The graphs in Fig. 3 show the average daily return and standard deviation for all markets in individual periods.

Whereas the standard deviation in Period 1 and Period 2 are very similar in all markets the average daily returns differ and Period 2 exhibits negative returns. Culmination of the financial crisis brought to the stock markets substantial volatility and remarkably negative average daily returns. The stabilization and post-crisis phases are characteristic of gradually decreasing of volatility to the pre-crisis levels. The rebound of returns in Period 4 was followed by stagnation in Period 5. The analysed stock markets became more homogeneous in Period 6 and showed very similar negative average daily returns with slightly increased standard deviations. Hence, none of the individual periods is similar to the others and, subsequently, the estimations of DWE are conducted separately for each period.

Fig. 3: Average daily return (in %) and standard deviation in individual periods



Source: Authors' calculations

Many alternative approaches and estimation techniques have been applied in literature to examine DWE. The classical methodology used in pioneer studies is the conventional OLS regression model with appropriately defined five dummy variables, each for one day of the week. Estimation of such regression model should be accompanied by a means test. This is necessary to verify if the returns are independent of the day they come from or they are characterised by statistically similar mean returns. Although this approach has been used extensively in previous research it suffers from two serious problems.

First, the residuals from the regression model can be autocorrelated, which results in misleading the inferences. This problem can be solved by extension of the model with lagged returns (e.g. one week lag). Second, there is no reason to assume that the variance of residuals will not vary over time. As it has been often documented by empirical evidence, the variance of residuals is not constant and possibly time-dependent. In this respect, Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model is able to capture the time-varying variability in the variance of the residuals. This approach has the advantage that the conditional variance can be expressed as a function of past errors. These models assume that the variance of the residual term is not constant through time.

In the present paper, we used the GARCH-M (1,1) model in the following specification:

$$R_t = \alpha_0 + \alpha_{MON} MO + \alpha_{TUE} TU + \alpha_{THU} TH + \alpha_{FRI} FR + \lambda h_t + \varepsilon_t \qquad (2)$$

$$h_t^2 = \alpha + \delta_{MON} MO + \delta_{TUE} TU + \delta_{THU} TH + \delta_{FRI} FR + \beta \varepsilon_{t-1}^2 + \gamma h_{t-1}^2 \qquad (3)$$

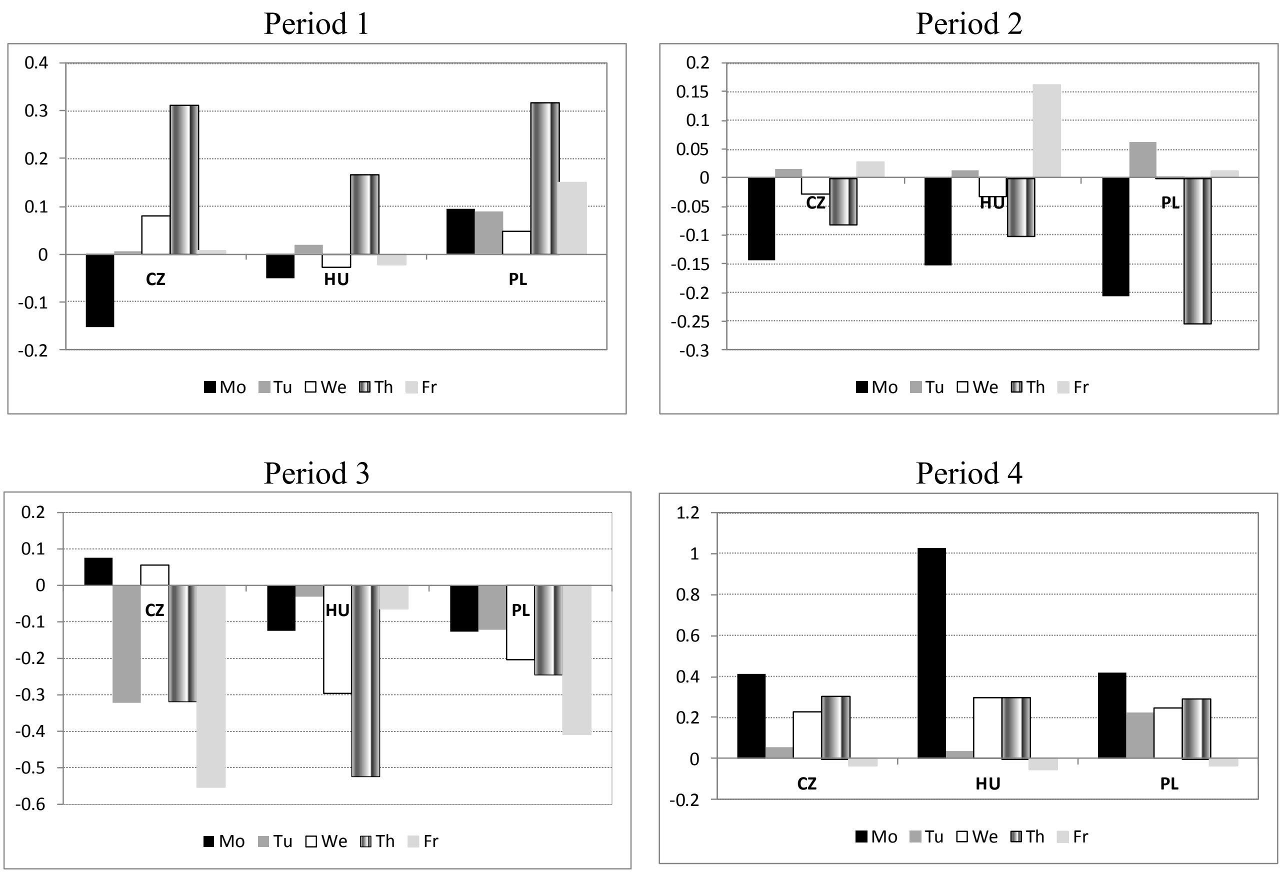
where R_t represents daily returns of an examined index. *MO, TU, TH* and *FR* are the dummy variables for Monday, Tuesday, Thursday and Friday, while we exclude the Wednesday's dummy variable from the equation to avoid the dummy variable trap. Further, h_t is the conditional variance, ε_τ denotes the residual term and λ is a measure of the risk premium, as it is possible that the conditional variance (proxy for risk) can affect stock market returns. If λ is positive the risk-averse agents must be compensated to accept the higher risk.

Given the fact that more risky assets may provide higher average returns we included the conditional variance in the conditional mean equation and used the GARCH-M model. Since our analysis is focused on very turbulent period of financial crisis we believe that it is worth to examine DWE not only in returns but also in volatility. Hence, we included the dummy variables also in the variance equation. Such a modification of the standard GARCH-M specification accounts for the possible stationary effects within the variance equation. Our approach finally leads to complex assessment of DWE in CE stock market indices as it captures both key factors of investments, i.e. return and risk.

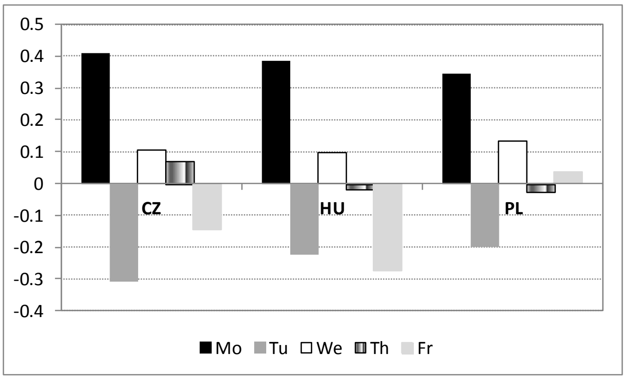
4. Estimation results

Before reporting results of our GARCH-M models' estimations we present a detailed graphical illustration of average daily returns in individual days of the week structured by periods and stock markets. The graphs in Fig. 4 show how different are the analysed periods.

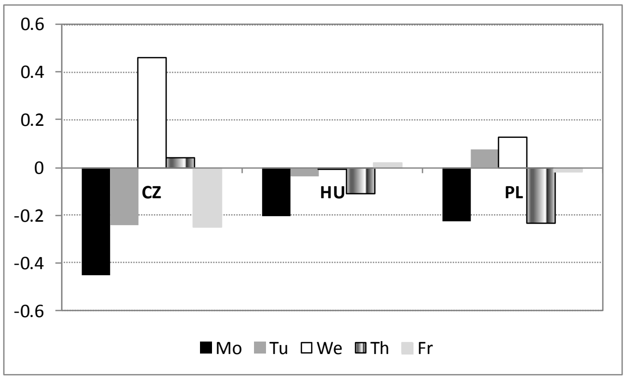
Fig. 4: Average daily return (in %) in individual days of the week



Period 5



Period 6



Source: Authors' calculations

While the markets seem to be quite homogeneous in some periods (e.g. Period 4 or Period 5) one can observe substantial differences in daily returns in the other periods. For example, during the period of crisis stabilization (Period 4) all markets exhibit Monday average return as the highest and Friday average return as the only negative in the week. Likewise, the size and order of remaining returns are very similar across the markets. By contrast, the period of crisis culmination, for example, brought a considerable diversity to daily returns. Although all daily average returns in Hungary and Poland are negative, the market declines the most on Thursday in Hungary and on Friday in Poland. On the other hand, the Czech market reports positive returns on Monday and Wednesday and most negative on Tuesday.

We estimated the GARCH-M (1,1) model according to the specification in (2) and (3) for all the countries and periods analysed. The obtained results are **p**resented in Tab. 3 – 5. The upper part of the table summarizes results for the mean equation and the lower part reports the results for the variance equation.

We run a battery of standard tests to check descriptive validity and specification adequacy of estimated models. In particular, we applied the ARCH-LM test and Ljung-Box Q Statistics on the standardized residuals and standardized squared residuals with 5, 10, 15 and 20-day lags. The tests reject the presence of auto-correlated residuals ARCH effects and support model specification for almost all GARCH-M models estimated. To conserve the space the results of these specification tests are not reported but may be obtained from the authors upon request.

As regards to the day of the week effect in the mean equation, the individual meaning for each one of the dummy variables could reveal the presence of an atypical yield during a day of the week with respect to that of Wednesday. Although we found some weak evidence of the effect presence the results are rather mixed and one can reveal no common pattern for all three stock markets. In addition, evidence of DWE is not stable over time as the significance and sign of individual dummy variables differ across the periods.

Tab. 3: Estimation of GARCH-M model for the Czech stock market

	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6
			Mean equation			
α_0	0.2507[a]	0.1661	0.4752[b]	0.0344	0.1529	0.4134
α_{MON}	-0.2162	-0.3005[b]	-0.4818	0.2968	0.1046	-0.8124[a]
α_{TUE}	-0.2075	-0.1421	-0.9689[a]	-0.1030	-0.3383	-0.6553[b]
α_{THU}	0.1466	-0.1803	-0.5479[b]	-0.1949	-0.0539	-0.4901[c]
α_{FRI}	-0.1610	-0.0018	-0.4645	-0.3867	-0.2347	-0.4514[c]
λ	-0.0055	0.0243	-0.0076	0.0809	0.0037	0.0074
			Variance equation			
α	-0.3189	-0.0233	0.2614	0.1432	0.4760	1.1935
δ_{MON}	0.7307[b]	-0.4098	-1.4415	-0.7476	-0.1499	-0.1010
δ_{TUE}	0.5351	0.3349	-0.1869	-0.1010	-0.5314	-1.6895
δ_{THU}	0.8234	0.1663	-0.3647	-0.2208	-0.8497	-2.0295
δ_{FRI}	-0.0722	0.1988	0.9855	0.5149	-0.7067[c]	-1.6438
β	0.1240[b]	0.2032[a]	0.1885[a]	-0.0391[a]	0.1064[b]	0.1516[a]
γ	0.8231[a]	0.8053[a]	0.8292[a]	1.0100[a]	0.8713[a]	0.8205[a]

Source: Authors' calculations
Note: [a], [b], [c] denote significance at 1%, 5% and 10% respectively

Tab. 4: Estimation of GARCH-M model for the Hungarian stock market

	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6
			Mean equation			
α_0	0.1453	-0.0301	0.3017	-0.2076	0.3509	-0.2565
α_{MON}	-0.0871	-0.1756	-0.4817	0.8400[b]	-0.1264	-0.1878
α_{TUE}	-0.0664	-0.0706	-0.2558	-0.1418	-0.3410	0.0731
α_{THU}	0.1423	0.0279	-0.3560	-0.0819	-0.3711	0.0095
α_{FRI}	-0.0785	0.1330	-0.4671	-0.1925	-0.4008	0.3042
λ	-0.0390	0.0619	-0.0159	0.0930	-0.0562	0.0745
			Variance equation			
α	-0.0530	0.3690	0.7635	-0.8869	0.4917	0.0553
δ_{MON}	0.3686	-0.2789	-1.1826	0.7112	-0.8914	0.3941
δ_{TUE}	0.2407	-0.1365	-0.7713	1.7669	0.0681	0.1927
δ_{THU}	0.8060	0.0972	-1.5002	1.4529	-0.7542	-0.4619
δ_{FRI}	-0.7674	0.1882	-0.0623	0.8716	-0.3911	-0.1990
β	0.1021[c]	0.3296[b]	0.1499[a]	0.0704[b]	0.1134[a]	0.1199[b]
γ	0.8597[a]	0.5040[a]	0.8549[a]	0.9164[a]	0.8456[a]	0.8701[a]

Source: Authors' calculations
Note: [a], [b], [c] denote significance at 1%, 5% and 10% respectively

Tab. 5: Estimation of GARCH-M model for the Polish stock market

	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6
Mean equation						
α_0	0.0795	-0.3611	-0.0654	0.2080	0.2156	0.0811
α_{MON}	0.0859	-0.0225	-0.1232	0.1988	0.0821	-0.3219
α_{TUE}	0.0011	0.1315	-0.1131	-0.1045	-0.3483[b]	0.0500
α_{THU}	0.1120	-0.0847	-0.1435	-0.2830	-0.2034	-0.2129
α_{FRI}	0.1063	0.0669	-0.2667	-0.5366[b]	-0.1168	-0.0395
λ	-0.0118	0.2466	0.0210	0.2211	-0.0321	0.0171
Variance equation						
α	-0.2778	-0.0309	-0.3452	-0.6168	-0.0305	0.4797
δ_{MON}	0.4720	-0.0815	1.3420	1.0904[a]	0.1141	-0.1963
δ_{TUE}	0.5753	0.3593	0.4270	0.2073	0.2113	-0.6240
δ_{THU}	1.5929[b]	0.5179	-0.3205	1.7767[b]	-0.0040	-0.5982
δ_{FRI}	-0.7755	-0.0083	0.7435	0.7921	-0.0690	-0.8653[b]
β	0.0551[c]	0.0914[c]	0.1229[b]	0.0644[c]	0.0610[b]	0.0888[b]
γ	0.8926[a]	0.8479[a]	0.8579[a]	0.9131[a]	0.9067[a]	0.8968[a]

Source: Authors' calculations
Note: [a], [b], [c] denote significance at 1%, 5% and 10% respectively

The estimation results are inconsistent with the usual concept of the day of the week effect that has been empirically revealed in most studies where average Monday returns are usually significantly lower and average Friday returns significantly greater than the average returns for the other days of the week. We only found that Monday's dummy variable is significantly negative in the Czech stock market in the pre-crisis period and period of sovereign-debt crisis. On the other hand, the only evidence of DWE discovered in the Hungarian market is opposite as the Monday returns seems to be significantly higher in the period of crisis stabilization. The evidence on DWE we picked up in the Polish market does not correspond with theoretical assumption either since the Friday average yield is significantly lower in the period of crisis stabilization. We further observe sporadic and isolated evidence of DWE in estimation results. Significantly lower returns are found on Tuesday for Poland in the post-crisis period and for the Czech Republic during the period of crisis culmination. Additionally, we uncover also lower return on Thursday in the Czech market during culmination of the crisis.

In the variance equation of the modified GARCH-M (1,1) model we allow the conditional variance to change for each day of the week. This is the way how we can examine the day of the week effect in volatility. The highest volatility as suggested by estimated coefficients occurred during the crisis culmination. However, the day of the week effect was not detected in volatility in this period. We did not find any evidence of the effect in the Hungarian stock market volatility at all. Some evidence was revealed in the remaining two markets; however it is rather exceptional. Results show significant effect of Monday and Thursday on conditional variance (volatility) in Czech and Poland's markets. In particular, Monday increases stock market volatility in the Czech Republic in the pre-crisis period and in Poland in the phase of crisis stabilization. Thursday increases volatility in Poland before the crisis (Period 1) and also during the stabilization (Period 4). Last, we revealed that Friday significantly reduces volatility of the Polish stock market volatility in the last period of sovereign-debt crisis.

5. Conclusion

This paper investigates the possible existence and change in nature of DWE in three CE stock markets during the recent financial crisis. The sample covers six periods that cover individual phases of the crisis. This is the first study focused on the CE region that uses the most recent data and examines DWE in daily returns as well as daily returns' volatility. The results suggest that the analysed stock markets seem to be mostly immune to DWE. In all markets and periods, we revealed only rare occurrence of calendar anomalies. This weak evidence is not consistent over time because significance and signs of the respective parameters change across the periods. Furthermore, the estimated coefficients are often contrary to theoretical expectations and findings of classical studies in this field. Hence, the occasionally revealed effects may be only stokes of luck of erratic movements in the stock market indices. Such a conclusion can be drawn on both daily returns and volatility. Our analysis, therefore, confirms conclusions of previous research, as referred to in this paper, that DWE is not typical for the CE stock markets. This characteristic did not change even during the financial crisis.

References

[1] AJAYI, R.A., MEHDIAN, S., PERRY, M.J. The Day-of-the-Week Effect in Stock Returns: Further Evidence from Eastern European Emerging Markets. *Emerging Markets Finance and Trade*, 2004, vol. 40, no. 4, pp. 53 – 62.

[2] APOLINARIO, R.M.C., SANTANA, O.M., SALES, L.J., CARO, A.R. Day of the week effect on European stock markets. *International Research Journal of Finance and Economics*, 2006, no. 2, pp. 53 – 70.

[3] BORGES, M.R. *Calendar Effects in Stock Markets: Critique of Previous Methodologies and Recent Evidence in European Countries*. ISEG Working Papers No. WP 37/2009/DE/UECE. Lisbon: Technical University of Lisbon, School of Economics and Management, 2009, 31 p.

[4] CHUKWUOGOR-NDU, C. Stock market returns analysis, day-of-the-week effect, volatility of returns: Evidence from European financial markets 1997-2004. *International Research Journal of Finance and Economics*, 2006, no. 1, pp. 112 – 124.

[5] CROSS, F. The Behavior of Stock Prices on Fridays and Mondays. *Financial Analysts Journal*, 1973, vol. 29, no. 6, pp. 67 – 69.

[6] FAMA, E.F. Efficient capital markets: A review of theory and empirical work. *Journal of Finance*, 1970, vol. 25, no. 2, pp. 383 – 417.

[7] FRENCH, K.R. Stock returns and the weekend effect. *Journal of Financial Economics*, 1980, vol. 8, no. 1, pp. 55 – 69.

[8] GAJDOŠOVÁ, K., HERYÁN, T., TUFAN, E. Day of the Week Effect in the European Emerging Stock Markets: Recent Evidence from the Financial Crisis Period. *Scientific*

Papers of the University of Pardubice, Series D, 2011, vol. 15, no. 19 (1/2011), pp. 38 – 51.

[9] GUIDI, F., GUPTA, R., MAHESHWARI, S. Weak-form Market Efficiency and Calendar Anomalies for Eastern Europe Equity Markets. *Journal of Emerging Market Finance*, 2011, vol. 10, no. 3, pp. 337 – 389.

[10] HANOUSEK, J., KOČENDA, E. Foreign News and Spillovers in Emerging European Stock Markets. *Review of International Economics*, 2011, vol. 19, no. 1, pp. 170 – 188.

[11] HÖGHOLM, K., KNIF, J., PYNNÖNEN, S. Common and local asymmetry and day-of-the-week effects among EU equity markets. *Quantitative Finance*, 2011, vol. 11, no. 2, pp. 219 – 227.

[12] KE, M.C., CHIANG, Y.C., LIAO, T.L. Day-of-the-Week Effect in the Taiwan Foreign Exchange Market. *Journal of Banking and Finance,* 2007, vol. 31, no. 9, pp. 2847 – 2865.

[13] LIM, S.Y., MUN HO, C., DOLLERY, B. An empirical analysis of calendar anomalies in the Malaysian stock market. *Applied Financial Economics*, 2010, vol. 20, no. 3, pp. 255 – 264.

[14] MALKIEL, B.G. The Efficient Market Hypothesis and Its Critics. *Journal of Economic Perspectives*, 2003, vol. 17, no. 1, pp. 59 – 82.

[15] PATEV, P., LYROUDI, K., KANARYAN, N.K. *The Day of the Week Effect in Central European Transition Stock Markets*. Finance and Credit Working Paper No. 03-06. Svishtov: D. A. Tsenov Academy of Economics, 2003. 21 p.

[16] PATHIRAWASAM, C., IDIRISINGHE, I.M.S.K. Market efficiency, thin trading and non-linear behaviour: Emerging market evidence from Sri Lanka. *E a M: Ekonomie a Management*, 2011, vol. 14, no. 1, pp. 112 – 122.

[17] STRAWIŃSKI, P., ŚLEPACZUK, R. Analysis Of High Frequency Data On The Warsaw Stock Exchange In The Context Of Efficient Market Hypothesis. *Journal of Applied Economic Sciences*, 2008, vol. 3, no. 5, pp. 306 – 319.

[18] SYRIOPOULOS, T. Dynamic linkages between emerging European and developed stock markets: Has the EMU any impact? *International Review of Financial Analysis*, 2007, vol. 16, no. 1, pp. 41 – 60.

[19] TONCHEV, D., KIM, T.H. Calendar effects in Eastern European financial markets: evidence from the Czech Republic, Slovakia and Slovenia. *Applied Financial Economics*, 2004, vol. 14, no. 14, pp. 1035 – 1043.

[20] YALCIN, Y., YUCEL, E.M. The Day-of-the-Week Effect on Stock-Market Volatility and Return: Evidence from Emerging Markets. *Finance a Úvěr - Czech Journal of Economics and Finance*, 2006, vol. 56, no. 5-6, pp. 258 – 277.

[21] ŽIKEŠ, F., BUBÁK, V. Seasonality and the Nontrading Effect on Central-European Stock Markets. *Finance a Úvěr - Czech Journal of Economics and Finance*, 2006, vol. 56, no. 1-2, pp. 69 – 79.