CALENDAR EFFECTS ON STOCK MARKET:
CASE OF SELECTED CIS AND CEE COUNTRIES

by

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Abstract

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This thesis investigated the existence of calendar effects for selected developing countries. The empirical analysis for the stock markets of selected CIS and CEE countries gives mixed evidence. Monday effect had only been found for a couple of countries by GARCH approach. Tuesday effect was not found for none of the countries. Friday effect had been detected by the bootstrap approach for 8 out of 13 countries while other approaches indicate the opposite. Day-of-the-month effect was found significant partly: returns for the beginning of the month are higher than for the rest of the month. Month-of-the-year effect had been found for a half of countries from the dataset however the dataset is too small to rely on these results.

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GLOSSARY

Calendar effects – effects of unusually high or low returns on the stock market depending on the calendar date

Day-of-the-month (DoM) effect – effect of higher returns associated with the calendar dates around the turn of the month (±5 days around the turn)

Day-of-the-week (DoW) effect – is associated with negative returns on Monday (or Tuesday) and positive returns on Friday

Friday effect – effect of significantly negative returns on Tuesday

Month-of-the-year (MoY) effect – is a tendency of stocks to give the highest returns in January comparing to the rest of the month

Monday effect – effect of significantly negative returns on Monday

Tuesday effect – effect of significantly negative returns on Tuesday

Chapter 1

INTRODUCTION

One of the Marc Twain's aphorisms says: "October. This is one of the peculiarly dangerous months to speculate stocks in. The others are July, January, September, April, November, May, March, June, December, August and February". However, it seems that this joke has less to do with humor then the author could have expected and there are indeed some seasonal patterns in the behavior of stock prices. These special patterns (whose existence, needless to say, is of particular interest not only for pure scientists but also for those who apply economic and mathematical results in the stock markets), called "calendar effects", have been studied thoroughly and intensively during more than 75 years.

In short, the calendar effects are the effects of unusually high or low average return depending on the date on the calendar (and that is why they are called calendar effects). For example, consider the case of the day-of-the-week effect (perhaps the most popular and studied effect out of the group of calendar effects). One can say that Monday returns measure the result of investment for 72 hours from Friday's close to Monday's close. Expected equity returns for Monday should therefore be higher than for 24-hour returns on other days of the week. An overwhelming evidence of US equities shows, however, that average Monday returns have been both lower and negative from 1897 until the 1980s (French (1980)). This anomaly is particularly puzzling because there seems to have been no compensation for accepting equity risk during the weekend and/or on Monday! Moreover, the efficient market hypothesis should cause all anomalies (not only of calendar type) to disappear once they are described by academics to the investment company because any profitable opportunities will be traded out of existence. Still, some researches of relatively recent time show that calendar effects have not disappeared even now (Lakonishok and Smidt (1988)), after more than seventy years have passed after they have been discovered by Fields in 1931! It has to be mentioned, however, that most of recent studies (Rubinstein (2001), Mabberly and Waggoner (2000), Sullivan (2001)) show that some of the effects are disappearing or losing power.

Studies of effects of that kind are rooting in the pioneering article by Fields going back in history as far as 1931 (Fields 1931). However, it has to be said that despite a number of articles concerned with the seasonal effects on the markets of the developed economies like USA, UK, Germany, Japan etc. have been published during this period, little has been done for transition and developing countries, in particular for CIS and CEE countries. Unsurprisingly, during the last years the studies of the stock markets in the transition countries had intensified noticeably. This can be explained by a greater average rate of returns in those markets comparing to the developed markets of Western Europe, Japan, Australia and USA and little or none correlation with the major markets making the diversification of investment possible.

The case of Ukraine could be, however, considered an exception among all other developing countries of Central and Eastern Europe as for many reasons Ukraine is a lagger in the process of creation and development of financial market and infrastructure[1]. Needless to say, now the time to start serious studies of the Ukrainian market has definitely come since we face the successful history of more then two years of continuous trades on the PFTS market and overwhelming growth of its index as well as growing interest of private as well as corporate clients in the Ukrainian stock market.

Researchers are not unanimous about the existence and the reasons for seasonal effects. Moreover, the results of tests for existence of seasonal effects for different countries and indices are quite ambiguous. For example, while day-of-the-week effect was stubbornly significant for S&P 500 index during 70s and 80s it has suddenly disappeared after 1987. A case of Ukraine is interesting to study since the underdevelopment of its financial and stock markets can lead to the violation of the Efficient Market Hypothesis (studies by Maliar (2005) and Nikulyak (2002) result in

[1] For example, a possibility to invest in index on the Ukrainian market was created only in fall 2007, while in Russia it was possible since 2004.

contradicting conclusion concerning this issue) and, thus, can lead to different biases like the seasonal effects.

The main goal of this thesis will be the investigation of existence of the calendar effects on the list of selected CEE and CIS stock markets (Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Lithuania, Poland, Romania, Russia, Slovakia, Slovenia, Ukraine). We will proceed with studying the following list of calendar effects[2]:

1. day-of-the-week effect[3]
2. day-of-the-month effect
3. month-of-the-year effect[4].

Day-of-the-month and month-of-the-year effects had not yet been studied for any of the abovementioned CEE and CIS countries. Moreover, studies of day-of-the-week had been done only for a nearly half of them (namely, for Romania, Hungary, Latvia, Russia, Slovakia, Slovenia, Poland and Czech Republic) and for the period of time preceding 2002. This is why we are going to study calendar effects for the developing countries.

[2] We do not study so-called size effect since the number of small enterprise listed on the PFTS market is too modest to satisfy the needs of analysis and testing.

[3] We do not follow Rogalski (1984) in his partitioning the day-of-the-week effect into two parts: so-called Monday effect and non-trading weekend effect since the data for the intraday stock index value for Ukraine will be quite hard if not impossible to get.

[4] We already expect the problems with testing for the this effect because of the more then meager data set available.

Chapter 2

LITERATURE REVIEW

Since the very nature of the calendar effects from the above list is quite different it will be reasonable to split literature review into parts according to the studied calendar effect.

a) Day-of-the-week effect.

Perhaps it would be reasonable to separate the literature review concerning the day-of-the-week effect into two parts: articles that are concerned with developed countries and those that deal with developing countries.

i) Developed countries.

Unsurprisingly, studies of calendar effects began with studies about American stock markets. As it was mentioned in the text above, the investigation of calendar effects begins with the four-page article by Fields (1931). M.J. Fields was the first to recognize the existence of special patterns in the intraweek returns. Even though no tests were conducted by Fields, his paper gave rise to a series of articles. It has to be said that until the end of 80s – beginning of 90s most articles advocated the existence of the day-of-the-week (DOW) effect while after the critique in the end of 80s a vast majority of them argued their existence. Among the early advocates of existence of the DOW effect an article by Cross (1973) is worth mentioning. Cross (1973) has not only extended the data set used by Fields by more then 40 years but also considered both the composite Dow-Jones index and other American indices. However, no statistical tests were contained in the article.

The work by F. Cross had been continued by French (1980) who was the first to put the studies of calendar effects on the rails of statistical testing and mathematical modeling. K. French had considered two alternative models of the process generating stock returns leading to different hypothesis, namely: the calendar time hypothesis and the trading time hypothesis. The former hypothesis assumes that the expected return for Monday is three times the expected return for other days of the week while the latter deals with the equal expected returns for each day of the week. During most of the period studied, from 1953 through 1977, the daily returns to the Standard and Poor's composite portfolio are inconsistent with both models. Although the average return for the other four days of the week was positive, the average for Monday was found out to be significantly negative during each of five-year sub-periods (both usual t-test and Bayesian approach had been used).

More or less strict mathematical approach accompanied with the broadening the field of markets involved into consideration had been continued in articles by Gibbons and Hess (1981), Rogalski (1984), Jaffe and Westerfield (1985), Condoyanni et al. (1987), Ziemba (1991) and Chang, Pinegar and Ravichandran (1993). We discuss these papers in the chronologic order.

Gibbons and Hess (1981) used simple linear regression on the dummies of the day of the week and then conducted the t-test.

Rogalski (1984) was the first to separate the DOW effect into two parts: Monday effect and non-trading weekend effect. He tested for their existence using the Gibbons' and Heim's simple linear regression (SLR) approach on S&P 500 and DJIA indices (author used the opening prices of the indices) and F- and t-tests. The results were surprising in the sense that only non-trading weekend effect was significant while the Monday effect was insignificant in his testing.

Jaffe and Westerfield (1985), Condoyanni et al. (1987), Ziemba (1991) all followed the same approach namely, they used the SLR model and conducted t- and F-tests afterward. The only difference between these articles were the markets under consideration: Japan, Australia, Canada, and the UK were studied by Jaffe and Westerfield (1985); Canada, Singapore, and the UK – Condoyanni et al. (1987); Japan from 1949 to 1988 – Ziemba (1991); and a list of European countries between 1986 and 1992 – Chang, Pinegar, and Ravichandran (1993). We have to say that they all have obtained negative average Monday returns and moreover, all they were statistically significant.

The revolutionary articles in studies of the DOW effect were ones by Connolly (1989, 1991). The traditional approach was abandoned in Connolly (1989, 1991) in favor of the robust econometric models (like Bollerslev's GARCH) and Bayesian approach to testing in order to deal with econometric problems appearing in the SLR (to mention few, these were nonnormality of the residuals, conditional heteroskedasticity of the residuals, and autocorrelation (weak, but nevertheless significant) among the daily returns).

Further development of studies of DOW effect resulted in the Sullivan et al. (2001). Authors used 100 years of daily data and a bootstrap procedure that allowed them to explicitly measure the distortions in statistical inference induced by data mining (that was proclaimed to be the reason of DOW effect). They've found that although nominal p-values for individual calendar rules are extremely significant, once evaluated in the context of the full universe from which such rules were drawn, calendar effects no longer remain significant.

A recent article by Rubinstein (2001) argues that DOW anomaly is even stronger than the literature suggests. He claims that for 12 non overlapping 5-year periods from 1928-1987 there were negative Monday returns, moreover it was also the worst day of the week. Furthermore, of the 55 overlapping 5-year periods between 1928 and 1987, Monday was always negative and, in all but one, the worst day of the week. At the same time, after 1987 the DOW effect disappeared. Indeed, from 1989-1998, Monday returns have not only been positive, but Monday has been the best day of the week.

ii) Developing countries

It has to be emphasized once again that literature on the developing countries is very meager. Despites this fact there were some researches that has to be highlighted. These are Chukwuogor-Ndu (2006) and Basher and Sadorsky (2006).

Chukwuogor-Ndu (2006) dealt with a list of 15 developing and developed European countries. The main argument of the article was that usually returns exhibit a non-normal distribution and thus usual t-test is not applicable. The day-of-the-week effect had been found in 7 out of 15 studied stock markets. Another important thing about the research is the so-called Tuesday effect (that is, negative mean return at Tuesday), that was found in several countries.

At the same time, the latter dealt with the stock markets of the developing markets all over the world. The data contained information from 21 emerging stock market. Notable is the fact that all tests were conducted for the so-called excess returns, that is, the difference between the daily yield on the stock market and the daily yield on the US T bill. Different models give contradicting results but markets in Philippines, Pakistan and Taiwan contain day-of-the-week regardless of the model.

Among interesting studies that are not yet published one could single out works (in brackets the market and the result of the work is given) by Nath and Dalvi (India, found day-of-the-week effect before 2002), Holden (Austria, Czech Republic, Germany, Hungary, Poland, UK, USA, no evidence of DOW effect), Patev, Lyroudi and Kanaryan (Romania, Hungary, Latvia, Czech Republic, Russia, Slovakia, Slovenia, Poland, ambiguous results) and Lyroudi and Subeniotis (Greece, some evidence pro existence).

b) Day-of-the-month effect.

Ariel (1987) reports a remarkable result that all of the US stock market's cumulative advance from 1963 to 1981 occurred in regular half-month periods. Average returns were only positive for the last trading day of the month and for trading days in the first half of the month during these years. This uncommonly effect is called day-of-the-month effect. These results still occur when large returns around the start of the year are excluded. Lakonishok and Smidt (1988) find evidence for the calendar anomaly back to 1897. They also show that positive average returns are particularly high for the four trading days that commence on the last trading day of the month. This turn-of-the-month anomaly has also been found for Nikkei index returns (Ziemba 1991) and for other countries (Jaffe and Westerfield 1989), but seems to disappear in the S&P 500 index after 1990 (Maberly and Waggoner 2000).

c) Month-of-the-year.

Rozeff and Kinney (1976) had shown that returns from the US stock indices were significantly higher at the start of the new tax year in January than in the other months, during the period from 1904 to 1974. Existence of these anomalously high returns in January is usually explained by so called *month-of-the-year effect*. Research in this field proceeded with the international study of Gultekin and Gultekin (1983) that found the January's average return to be significantly higher than in the other months for thirteen of the seventeen studied countries. The most popular explanation of the significance of January effect in the US market is the tax-loss selling hypothesis of Brown, Keim, Kleidon, and Marsh (1983). They argue that selling pressure at the end of the tax year depresses the prices that rebound back in January. The hypothesis is supported first by absence of the January effect before 1917, when there was no incentive to sell for the tax reasons (Schultz 1985), and second by the year-end trading behavior of individual investors (Ritter 1988). However, the effects b) and c) were not that significant as the day-of-the-week effect did.

Taking all these into account, this thesis is aspired to investigate the existence of calendar effects using two following models:

a. Linear regression on dummies, GARCH on dummies, bootstrap approach, Bayesian approach for day-of-the-week effect

b. Linear regression on dummies for day-of-the-month and month-of-the-year effect

This research contributes to the existing literature by exploring the question of stock return autocorrelation in continuously trading Ukrainian stock market, stock markets of Baltic and Balkan countries.

C h a p t e r 3

DATA DESCRIPTION

For the empirical analysis and testing we used a time series consisting of the daily data on indices of the main thirteen Central and Eastern European stock markets including Russia and Ukraine. The choice of indices rather than the individual stocks is motivated by the fact that the vast majority of all researches concerning the calendar effects utilize data on country indices.

The following table helps to give a first impression about the available data:

Table 1. General information about the data

Country	**Index**	**Length of sample**	**# of observations**
Bulgaria	BSE	24.10.2000-16.04.2008	1852
Croatia	CROBEX	14.06.2002-16.04.2008	1401
Cz. Republic	PSE	05.04.1994-16.04.2008	3425
Estonia	TALSE	31.12.1998-16.04.2008	2352
Hungary	BSE	17.06.1993-16.04.2008	3708
Latvia	RIGSE	03.01.2000-16.04.2008	2127
Lithuania	VILSE	04.01.2000-16.04.2008	2057
Poland	WSE	21.06.1993-16.04.2008	3577
Romania	BET	07.01.1998-16.04.2008	2505
Russia	RTS	01.09.1995-16.04.2008	3137
Slovakia	SSI	19.10.1993-16.04.2008	3464
Slovenia	STM	05.01.1999-16.04.2008	1844
Ukraine	PFTS	12.01.1998-16.04.2008	2510

Data was collected from the Bloomberg database along with certain addition from the websites of the countries' stock exchanges[5].

As we are interested in the behavior of returns primarily rather than the behavior of indices themselves the choice of the returns definition might seem to be crucial. However, as our further findings show, in our case the choice of the returns definition is a matter of taste and does not play much role. However, we had to choose the measure and decided to stick to the following definition of daily returns[6]:

$$R_t = \frac{S_t - S_{t-1}}{S_{t-1}},$$

where S_t - is an index price.

Next two tables present respectively the overall descriptive statistics of available data for all indices and the descriptive statistics of the returns on the day-to-day basis for selected countries. Appendix A contains the plots of returns from selected CEE and CIS countries over time that allow one an eye-ball testing for constant variance (that is conducted formally in the Chapter 5), stationarity of these time series and other possible features of interest.

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5 Bulgaria (http://www.bse-sofia.bg), Croatia (http://www.zse.hr), Czech Republic (http://www.pse.cz), Estonia (http://www.ee.omxgroup.com), Hungary (http://www.bse.hu), Latvia (http://www.lv.omxgroup.com), Lithuania (http://www.lt.omxgroup.com), Poland (http://www.wse.com), Romania (http://www.bvb.ro), Russia (http://www.rts.ru), Slovakia (www.bsse.sk), Slovenia (http://www.ljse.si), Ukraine (http://www.pfts.com)

6 Monthly returns that were used in the studies of the month-of-the year effect were calculated in similar manner.

Table 2. Descriptive statistics.

Country	Mean	Median	Standard deviation	Min	Max	Skewness	Kurtosis
Bulgaria	.0018361	.0014616	.0196953	-.1921756	.2321305	.4057634	29.92438
Croatia	.0012513	.0013361	.0142696	-.0869926	.1753872	1.084659	22.38945
Cz. Republic	.0004099	.0007149	.0141963	-.073808	.1063607	-.1083926	5.623293
Estonia	.0010275	.0008063	.0125068	-.0565174	.1458626	.8016747	13.76433
Hungary	.0009226	.0010637	.0182498	-.156919	.1465412	-.3956745	11.12141
Latvia	.0010282	.0005573	.0155648	-.1367759	.0992443	-.6746616	19.34802
Lithuania	.0010819	.0009891	.0103894	-.0971179	.0468658	-.3973434	8.462877
Poland	.0009265	.0006652	.0217523	-.1509632	.1958426	.0712733	9.921232
Romania	.0006642	.0002829	.0202368	-.1886605	.1855774	.057903	14.38595
Russia	.0013496	.0019557	.0271472	-.1902465	.1683221	-.0793721	8.77331
Slovakia	.0007162	.0007124	.0176431	-.1170831	.3172548	2.417167	44.22755
Slovenia	.00181	.0014616	.0166761	-.0934902	.092921	-.0103608	8.678261
Ukraine	.0008625	.0009733	.0228824	-.1539051	.2217046	.0535841	15.25559

Table 3. Day-by-day descriptive statistics.

Name of the country	*Ukraine*	*Latvia*	*Lithuania*	*Estonia*	*Croatia*	*Hungary*
Monday	0.00137 (0.02399)	-0.0027 (0.01554)	-0.0003 (0.01101)	0.0004 (0.01438)	-0.00029 (0.01779)	0.00198 (0.01927)
Tuesday	-0.0009 (0.02021)	0.0086 (0.01337)	0.00094 (0.01040)	0.00149 (0.01224)	0.00298 (0.01335)	0.0091 (0.01698)
Friday	0.0013 (0.02185)	0.00195 (0.01667)	0.001663 (0.01028)	0.00151 (0.01241)	0.0006 (0.01237)	0.00145 (0.01708)

(Standard errors are in parenthesis)

The first issue that is becomes clear while looking at the table is that higher return is usually associated with the higher risk, that is, countries that have the highest mean (like Bulgaria, Croatia, Slovakia and Ukraine) usually have the highest standard deviation. These countries are also among those whose minimum and maximum values lay the most far from the mean and median points. This can be explained by the high volatility on these markets as measured by the standard deviation.

Another issue that crucial is the high value kurtosis (more than 5 for all indices, reaching 44 for Slovakia) for all indices that indicates that the distribution of the returns is peaked (i.e. leptokurtic, see Appendix B for graphical details). At the same time, skewness seems not to follow the same pattern for all distribution, being positive for some of the countries and negative for the rest. Even without formal testing for normality, it is clear that returns follow different distribution.

Table 3 summarizes the data on the day-by-day returns for the selected countries. It gives contradicting intuition concerning the existence of the day-of-the-week effect. While Monday average return takes both positive and negative values, Friday mean is persistently positive. This means, that at least one half of the day-of-the-week effect is preliminarily supported by the data available[7].

[7] We do not give descriptive statistics for the rest of the effects since they give very similar to Table 3's results.

Chapter 4

METHODOLOGY

In this thesis we studied three types of calendar effects:

a. Day-of-the-week effect

b. Day-of-the-month effect

c. Month-of-the-year effect.

Let us discuss the methodologies used for each of them in turn.

a) Day-of-the-week effect

This effect had been studied using 4 different methodologies:

I. Linear regression on dummies (and it's variations);

II. GARCH (Generalized autoregressive conditional heteroskedasticity) on dummies;

III. Bootstrap approach;

IV. Bayesian approach.

Let us consider them step by step.

I. The day-of-the-week effect had been studied intensively for the developed countries since the end of 70's. As most researches employ the **simple linear regression model** (to mention few French (1980), Gibbons and Hess (1981), Jaffe and Westerfield (1985) et al.), we will also use the model of this sort:

$$R_t = c_0 + \sum_{i=1}^{4} c_{it}\delta_{it} + \varepsilon_{it}$$

Here R_t is a daily return on the stock market (returns were calculated in two different ways, $R_t = \frac{S_t - S_{t-1}}{S_{t-1}}$ and $R_t = \ln(S_t) - \ln(S_{t-1})$, however the results were almost the same), δ_{it} are dummies for the days of the week (Monday, Tuesday, Thursday and Friday).

After estimating the model, all kinds of hypothesis concerning the DOW effect can be tested. That is, we are not going to concentrate only on Monday and Friday effect. As some researches show (see Basher and Sadorsky (2006), for example), for countries that lie in Western Hemisphere Monday effect is not valid while Tuesday effect arises. This can be explained by the correlation with the American market and the time difference. So, the following set of hypothesis is going to be tested:

a) $H_0 : c_1 < 0$ (Monday effect)

b) $H_0 : c_2 < 0$ (Tuesday effect)

c) $H_0 : c_4 < 0$ (Friday effect).

However, as Connolly (1989, 1991) claim, several specific problems may arise while using this approach:

a) the returns are likely to be autocorrelated;
b) the residuals are possibly non-normal;
c) the issue of heteroskedasticity may arise;
d) outliers with high/low value of return may distort the overall picture.

We will test for the existence of these problems and try to solve them using either alternative models (autocorrelation and heteroskedasticity issues are solved using

GARCH) or different estimating techniques (robust option in Stata to solve the heteroskedasticity problem) or simply by dropping the outliers.

II. **GARCH approach** was first suggested by Connolly (1989). He claimed: "Much of the empirical work on the weekend effect rests on a foundation of simple econometric models with strong statistical assumptions. These foundations are rarely, if ever, evaluated systematically. The importance of the stock return anomalies issue for finance research certainly justifies a healthy suspicion of any untested assumption."

As our empirical findings indicate, he was absolutely correct in doubting the appropriatness of the assumptions, that is, residuals are non-normal, exhibit an autocorrelated pattern and do not have constant variance. This are problems that GARCH model might be able to fix. So, the GARCH(1,1) model that we used looks like this:

$$\mathrm{R}_t = c_0 + \sum_{i=1}^{4} c_{it}\delta_{it} + \varepsilon_{it} ,$$

$$\sigma_t^2 = a + \beta_1\sigma_{t-1}^2 + \gamma_1\mathrm{R}_{t-1}^2 ,$$

where all previous notations apply and σ_t^2 is conditional time-dependent variance. After estimating the regression equation coefficients and the variance equation coefficients we are able to test the same hypotheses as described in point I.

III. Another approach used in this thesis is **bootstrap.** The pioneering article concerning the use of bootstrap for the calendar effects was the one by Sullivan, Timmermann and White (2001). Their main argument was that calendar effects are mainly "chimeras" and the products of data mining. Another argument was that these calendar effects were just an accident that could be ruled out of existence using the bootstrap technique. In short, bootstrapping is the practice of estimating properties (its variance, e.g.) of an estimator (mean, in our case) by measuring those properties when sampling from an approximating distribution. The most commonly used one is the empirical distribution. A number of resamples from the original dataset is being constructed using the random sampling with replacement. It is also often used for hypothesis testing. For example, we may construct the so-called bootstrap percentile intervals. It is done by taking the α and 1 − α quantiles of the estimated values of the parameter of interest. See Appendix C for the Matlab code.

We have employed the variation of bootstrap called *nested bootstrap* to calculate the confidence intervals for means for Monday, Tuesday and Friday. It allowed us to test the same hypotheses as in points I and II.

IV. Another pioneering technique in studies of calendar effects that was proposed by Connolly (Connolly (1991)) was the **Bayesian approach.** His major claim was: "The choice of Bayesian methods is not trivial. Much of the difference in empirical results can be traced directly to reliance on posterior odds, rather than standard F-tests based on conventional (fixed) significance levels. The potential for distorted inferences from hypothesis tests using large sample sizes but a fixed significance level strongly argues in favor of the posterior odds approach." This is closely related to the Lindley's paradox that occurs when the p-value indicates the rejection of the null while the posterior probability of null is high.

For the purpose of our thesis we considered three alternative models:

$$M_1 : \mathrm{R}_t = c_0 + \sum_{i=1}^{4} c_{it}\delta_{it} + \varepsilon_{it}$$

$$M_2 : \mathrm{R}_t = c_0 + \sum_{i=1}^{3} c_{it}\delta_{it} + \varepsilon_{it}$$

$$M_3 : \mathrm{R}_t = c_0 + \sum_{i=1}^{3} c_{it}\delta_{it} + \varepsilon_{it}$$

Model M_1 is our usual model, while M_2 does not contain Monday dummy and M_3 does not contain Friday dummy. We define marginal likelihood of a model M as following:

$$p(x \mid M) = \int p(x, \theta \mid M) p(\theta \mid M) d\theta,$$

where x – observed data, θ – model parameters. Next, we define the Bayes factor for two models M_1 and M_2 as following:

$$K = \frac{p(x \mid M_1)}{p(x \mid M_2)}.$$

For example, if models are nested like our models M_1 and M_2, Bayes factor could be used to test the hypothesis H_0 : Monday dummy's significant (i.e. Monday mean is statistically different from zero). The following decision rule should be applied:

Table 4. Decision rule using Bayes factor.

Value of Bayes factor	Evidence in favor of H_0
<1	accept H_1
1 to 3.2	not worth more than a bare mention
3.2 to 10	substantial
10 to 100	strong
>100	decisive

This table is based on Kass and Raftery (1995). See the Appendix D for the sample program from Matlab that calculates the Bayes factor (it utilizes BACC addon for Matlab that should be preinstalled in order for program to work properly).

b), c) Day-of-the-month effect and month-of-the-year effects

These two effects were studied using the usual linear regression model. The model for the day-of-the-month looks like this:

$$R_t = \beta_0 + \beta_1 Begin_t + \beta_2 End_t + \varepsilon_t,$$

where R_t is a return defined above, $Begin_t$ is a month beginning dummy (=1 if day is <5, 0 otherwise), End_t is a month end dummy (=1 if day is >25, 0 otherwise). The hypotheses tested where:

$$H_0 : \beta_1 > 0 \text{ and } H_0 : \beta_2 > 0 .$$

The model for the month-of-the-year effect was like this:

$$\widetilde{R}_t = \beta_0 + \beta_1 J_t + \varepsilon_t ,$$

where $\widetilde{R}_t$ were the monthly returns and J_t was the January dummy. The hypothesis tested was:

$$H_0 : \beta_1 > 0 .$$

C h a p t e r 5

RESULTS

As in this thesis we have studied three types of calendar effects: day-of-the-week effect, day-of-the-month effect, month-of-the-year effect, let us consider the results for these effects one after another.

a) Day-of-the-week effect

We will present the results from different approaches in tables that follow. First of all, we present the linear regression results $R_t = c_0 + \sum_{i=1}^{4} c_{it}\delta_{it} + \varepsilon_{it}$ (returns are calculated as $R_t = (S_t - S_{t-1}) / S_{t-1}$, see Appendix F for comparison with alternative approach).

Table 5. Simple linear regression

Country	Monday	Tuesday	Friday
1) Bulgaria	-.0024244	-.0008339	.0002284
2) Croatia	-.0015973	.0016715	-.0007066
3) Czech Republic	.0000183	.0009829	.0009099
4) Estonia	-.0008293	.0006155	.0006407
5) Hungary	.001587	.0006126	.0011461
6) Latvia	-.0008897	.0002359	.0013319
7) Lithuania	-.001248	-.0002781	.0004117
8) Poland	.0025571**	.0002112	.0016868
9) Romania	-.0013879	-.0000692	.0011365
10) Russia	.003762*	.0026567	.0043438**
11) Slovakia	.0012842	.0013233	.0017749
12) Slovenia	-.0021356	-.001238	.0009181
13) Ukraine	-.0005821	-.002051	-.0007761

* - Significant at 1%
** - Significant at 5%

As Table 5 indicates, the only effect that is found in a proper way is a Friday effect for Russia. However, as Appendix E indicates, regression is plagued by the following problems: non-normality, heteroskedasticity and autocorrelation for almost all countries.

Appendix F contains a list of alternative estimation techniques to simple linear regression model:

1. simple linear regression with returns calculated like $R_t = \ln(S_t) - \ln(S_{t-1})$;
2. `reg` with `robust` option enabled in Stata;
3. `reg` with `robust` option enabled in Stata and with outliers dropped (we dropped 4 max and 4 min values for each country);

However, the results seem not to differ as we switch from one model to another. The only more or less consistent finding is the real Friday effect fo Russia, that, however, was already in simple linear regression.

The next approach is GARCH:

Table 6. GARCH

Country	Monday	Tuesday	Friday
1) Bulgaria	-.0013639	-.0010197	-.0001185
2) Croatia	-.0019807*	.0013326	-.0005288
3) Czech Republic	.0002395	.0004327	.0004834
4) Estonia	-.0008489	.0005309	.0005605
5) Hungary	.0017694**	.0004135	.0014462*
6) Latvia	-.0012089	.0006021	.0010805
7) Lithuania	-.0013977**	-.0003194	.0005039
8) Poland	.0019009**	.0004261	.0022462*
9) Romania	.0001097	.0009618	.0016181
10) Russia	.002103*	.000795	.0022674*
11) Slovakia	.0004032	.0002438	.0012998
12) Slovenia	-.0014987	-.0010868	.0000313
13) Ukraine	-.001082	-.0012578	.0003737

* - Significant at 1%,
** - Significant at 5%

GARCH methodology was able to unearth two real Monday effects: for Croatia and Lithuania. However, the fact that the same methodology found the contrary effect for Poland seems to even out this happy fact. Hungary, Poland and Russia are enjoying the Friday effect. However, as I was saying it seems to be a data mining result mostly.

We proceed with the bootstrap approach.

Table 7. 95% confidence intervals for means constructed using nested bootstrap method

Name	Monday	Tuesday	Friday
1) Bulgaria	(-0.0022, 0.0030)	(2.41e-005, 0.0036)*	(0.0011, 0.0047)*
2) Croatia	(0.0010, 0.0043)*	(9.174e-004, 0.0054)*	(-7.749e-004, 0.0020)
3) Czech Republic	(-0.0014, 0.0012)	(-5.808e-004, 0.0022)	(-4.825e-004, 0.0019)
4) Estonia	(-0.0013, 0.0021)	(3.63e-004, 0.0022)*	(1.66e-004, 0.0031)*
5) Hungary	(5.293e-004, 0.0033)*	(4.339e-004, 0.0032) *	(1.15e-004, 0.0028)*
6) Latvia	(-0.0013, 6.719e-004)	(-5.608e-004, 0.0025)	(3.44e-004, 0.0034) *
7) Lithuania	(-0.0014, 0.0012)	(-4.931e-004, 0.0023)	(5.104e-004, 0.0031) *
8) Poland	(2.594e-004, 0.0045)*	(-0.0016, 0.0015)	(-4.927e-004, 0.0030)
9) Romania	(-0.0026, 0.0011)	(-0.0018, 0.0027)	(3.481e-004, 0.0033)*
10) Russia	(4.267e-004, 0.0042)*	(-0.0020, 0.0042)	(1.498e-004, 0.0057)*
11) Slovakia	(-7.353e-004, 0.0027)	(-8.306e-004, 0.0027)	(-2.601e-004, 0.0027)
12) Slovenia	(-0.0012, 0.0011)	(-0.0015, 8.262e-004)	(8.719e-004, 0.0033)*
13) Ukraine	(-0.0014, 0.0043)	(-0.0020, 0.0022)	(-0.0018, 0.0039)

* - significant at 95% confidence level

As the Table 7 indicates, there is no Monday effect in the traditional understanding. However, it has been discovered that there is as opposite Monday effect: instead of being negative, means are positive for Croatia, Hungary, Poland and Russia. At the same time, Friday effect's fans are in buoyant mood as it is significant (and goes the same direction we expect it to go) for Bulgaria, Estonia, Hungary, Latvia, Lithuania, Romania, Russia and Slovenia.

The last but not the least valuable methodologe that we used is the Bayesian approach. Table 8 gives the Bayes factors for the models M_1, M_2 and M_3 defined as they were defined in the methodology part of the thesis.

Table 8. Bayes factors

Country	M_1 **vs.** M_2	M_1 **vs.** M_3
1) Bulgaria	0.680382595	0.6734847
2) Croatia	0.59542491	0.5939679
3) Czech Republic	0.59077503	0.59101138
4) Estonia	0.5941937	0.5913957
5) Hungary	1.0594395	1.0329616
6) Latvia	0.6777072	0.6730403
7) Lithuania	0.703230894	0.697362442
8) Poland	0.93490534	0.98367473
9) Romania	0.74955918	0.74529885
10) Russia	0.9112664	0.8946703
11) Slovakia	0.6724954	0.6674305
12) Slovenia	0.537353	0.5299726
13) Ukraine	0.697264818	0.687406128

As Table 4 suggests, values of Bayes factor signal the total domination of alternatives over the null (the only value of Bayes factor that is greater then 1 is 1.0594 and is suggested to be treated as "not worth more than a bare mention" evidence pro null hypothesis). This means that Bayesian approach suggests that no day-of-the-week effect indeed exist.

We conclude our results with the tables concerning the rest of the effects.

b), c) day-of-the-month effect, month-of-the-year effect

Next page contains the joint table for testing the DOM and MOY effects. Results can be summarized as following:

b) day-of-the-month effect

The beginning of the month dummy is significant for 6 out of 13 countries while the end of the month dummy is significant for 4 out of 13 countries. A composite day-of-the-month effect is found significant only for Slovenia. However, once we allow the day-of-the-month effect to exist if at least one

Table 9. Day-of-the-month effect and month-of-the-year effect

Country	Beginning of the month	End of the month	January dummy
1) Bulgaria	-0.0016106	0.0029828**	.0152894
2) Croatia	0.0029828	0.0031635*	.0094409
3) Czech Republic	0.0006972	-0.0003329	.0525465**
4) Estonia	0.0014986	0.0009734	.0809981**
5) Hungary	0.0030883*	0.0011997	.0745937**
6) Latvia	-0.0004079	0.0004709	.0178991
7) Lithuania	-0.0001343	0.0012988**	.0259892
8) Poland	0.0027641*	-0.001161	.0708344*
9) Romania	0.0017652**	0.0003203	.030439
10) Russia	0.0036765**	-0.0024462	.0906369
11) Slovakia	0.001735**	0.0004391	.0346805*
12) Slovenia	0.0013328*	0.001413**	.0230542
13) Ukraine	-0.0022688	0.0013142	.0910259*

* - Significant at 1%,
** - Significant at 5%

part of it significant, it appears in 10 out of 13 countries. However, the results should not be overestimated since as we have seen in the case of simple linear regression for DOW effect, it has a lot of drawbacks.

b) Month-of-the-year effect

This effect seem to be the most successful among his mate effects as the coefficient is significant for 6 out of 13 countries, the direction of the effect is consistent with the hypothesis and the estimated coefficients (even those who are insignificant) all are positive.

Chapter 6

CONCLUSIONS

The main goal of this thesis was to study the existence of the calendar effects on the stock markets of the selected CEE and CIS countries and try to explain these effects in case they are present. We considered the following calendar effects:

d. Day-of-the-week effect

e. Day-of-the-month effect

f. Month-of-the-year effect

To detect the existence of calendar effects we applied the following statistical/econometrical methods:

c. Linear regression on dummies, GARCH on dummies, bootstrap approach, Bayesian approach for day-of-the-week effect

d. Linear regression on dummies for day-of-the-month and month-of-the-year effect

We found little evidence of existence of the day-of-the-week effect.

Usual regression models like linear regression on dummies found sporadic evidence of either Monday or Friday or Tuesday effect. At the same time alternative GARCH methodology was the only methodology that was able to discover significant negative returns on Monday for at least a few countries.

Bootstrap approach signals that there is no Monday effect at all in the traditional sense, while it detected significant Friday effect for 8 out of 13 countries.

Bayesian approach suggests that neither Monday nor Friday nor Tuesday effects exist for any of the countries from the dataset.

The day-of-the-month effect was found to be partly significant in nearly half of the examined countries.

The month-of-the-year effect was found for the half of countries, with the direction of the effect consistent with what had been predicted. However, the quality of the results concerning the month-of-the-year effect should not be overestimated due to the small number of observations.

The findings are consistent with recent findings concerning the day-of-the-week effect for developing countries. The results for month-of-the-year and day-of-the-month effects are novel and have no analogues for the developing countries. However, the quality of results for month-of-the-year is plagued by the inevitable fact that datasets are still too short.

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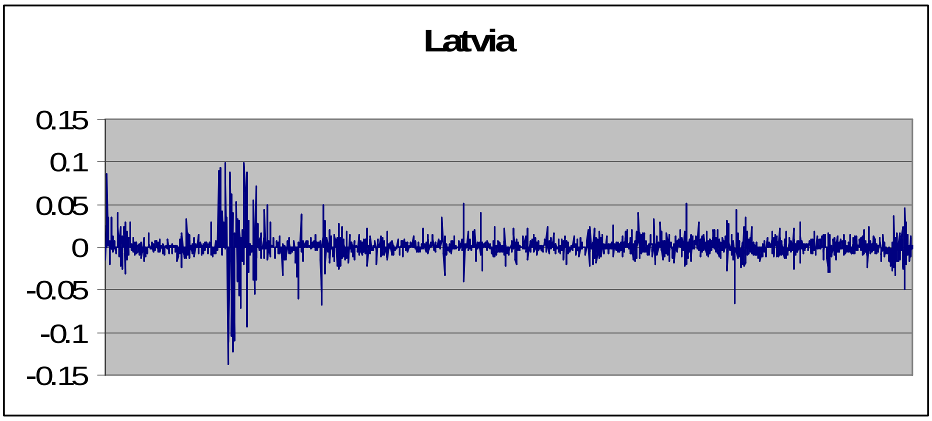
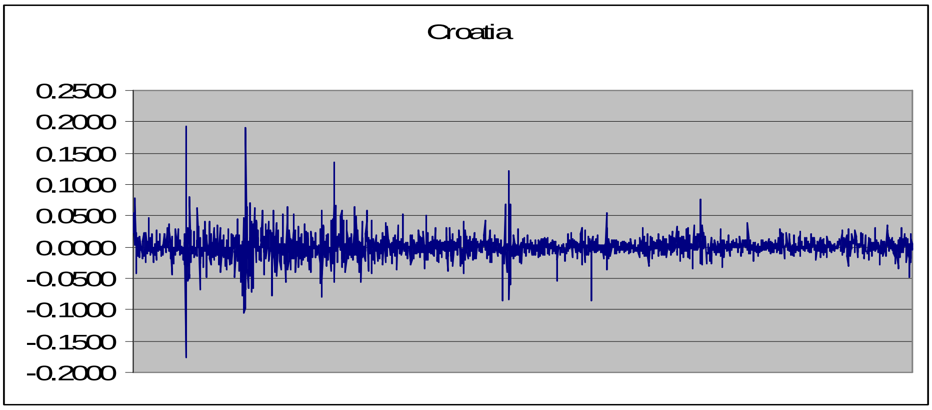
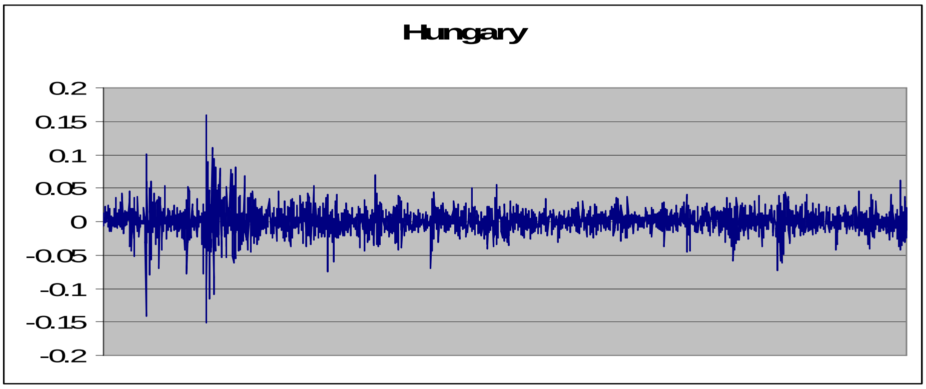
APPENDIX

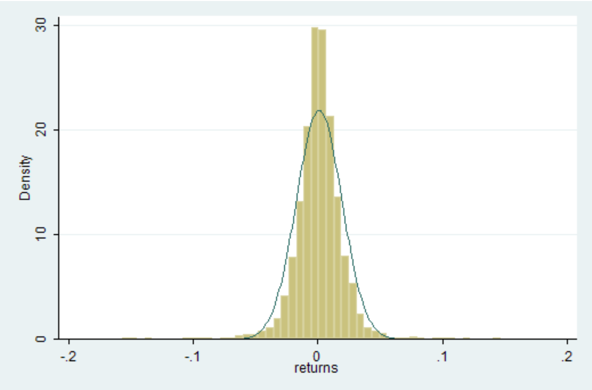
Appendix A. Returns performance over time



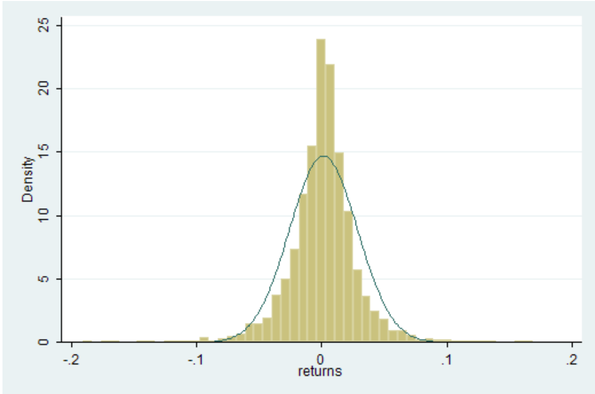




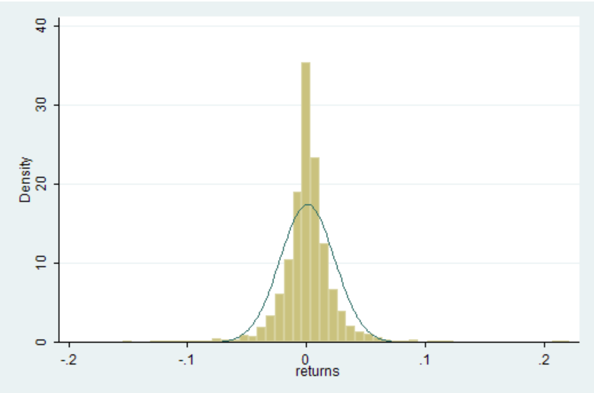
Appendix B. Normal vs. empirical cdf's of the returns.



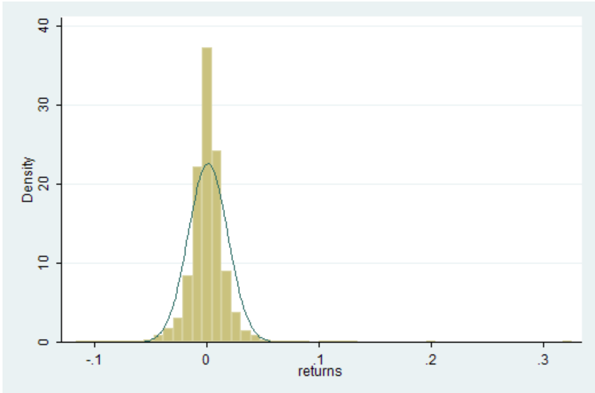
Hungary



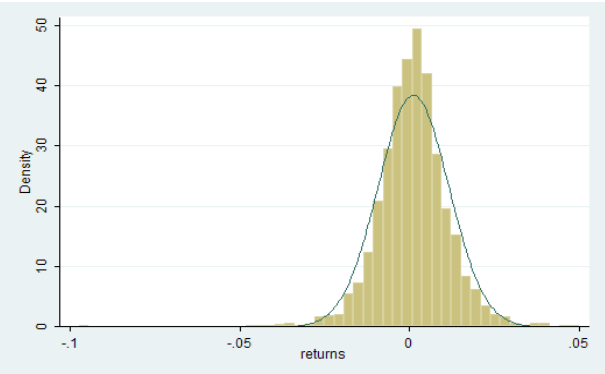
Russia



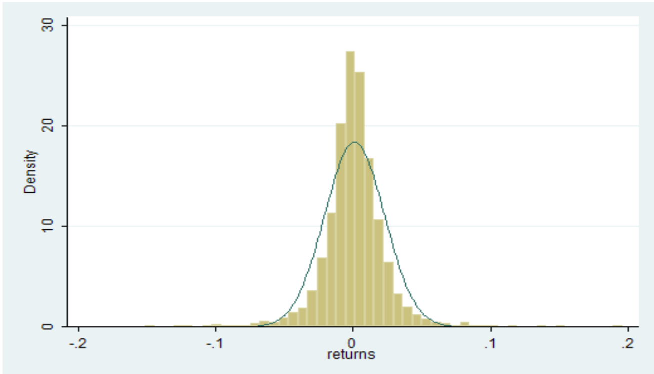
Ukraine



Slovakia



Lithuania



Poland

Appendix C. Matlab code for bootstrap confidence intervals.

```
function[Lo,Up]=confint(x,statfun,alpha,B1,B2,varargin)
%
%       [Lo,Up]=confint(x,statfun,alpha,B1,B2,PAR1,...)
%
%       Confidence interval of the estimator of a parameter
%       based on the bootstrap percentile-t method
%
%      Inputs:
%            x - input vector data
%      statfun - the estimator of the parameter given as a
Matlab function
%       alpha  - level of significance (default alpha=0.05)
%           B1 - number of bootstrap resamplings (default
B1=199)
%           B2 - number of bootstrap resamplings for
variance
%                estimation (nested bootstrap) (default
B2=25)
%     PAR1,... - other parameters than x to be passed to
statfun
%
%      Outputs:
%          Lo - The lower bound
%          Up - The upper bound
%
%      Example:
%
%      [Lo,Up] = confint(randn(100,1),'mean');


%  Created by A. M. Zoubir and D. R. Iskander
%  May 1998
%  Edited by Andriy Klesov
%  May 2008

pstring=varargin;
if (exist('B2')~=1), B2=25; end;
if (exist('B1')~=1), B1=199; end;
if (exist('alpha')~=1), alpha=0.05; end;

x=x(:);
vhat=feval(statfun,x,pstring{:});
[vhatstar,ind]=bootstrp(B1,statfun,x,pstring{:});

if length(pstring)~=0,
  if length(pstring{:})==length(x)
     newpstring=pstring{:};
     bstats=bootstrp(B2,statfun,x(ind),newpstring(ind));
```

```
  else
     bstats=bootstrp(B2,statfun,x(ind),pstring{:});
  end;
else
  bstats=bootstrp(B2,statfun,x(ind),pstring{:});
end;
bstat=bootstrp(B2,statfun,x,pstring{:});
sigma1=std(bstat);

q1=floor(B1*alpha*0.5);
q2=B1-q1+1;
sigma=std(bstats)';
tvec=(vhatstar-vhat)./sigma;
[st,ind]=sort(tvec);
lo=st(q1);
up=st(q2);
Lo=vhat-up*sigma1;
Up=vhat-lo*sigma1;
```

Appendix D. Sample Matlab code for Bayes factor calculating

```
y = xlsread('Ukraine.xls',-1);
mofri = xlsread('Ukraine.xls',-1);
stats = [mean(y)',std(y)']
[T,num1]=size(y)

% mofri ----> k=4, mothu, tuefri ----> k=3
k=4;
%     plug here mean of y
ymeanabout=0.1709;
%     plug here std of y
ystdabout=0.0229;
H_ = (k/T*(ystdabout^2))*mofri'*mofri;
beta_ = [ymeanabout; zeros(k-1,1)];
mod1 = minst('nlm', 'beta', 'h', beta_, H_, nu_, s_, mofri,
y);
nBurn=100;
nIter=10000;
postsim(mod1, nBurn+nIter, 1);
sim1 = postfilter(mod1, [(nBurn+1):(nBurn+nIter)]);
marg1 = mlike(mod1);

tuefri = xlsread('Ukraine.xls',-1);
k=3;
%     plug here mean of y
ymeanabout=0.1709;
%     plug here std of y
ystdabout=0.0229;
H_ = (k/T*(ystdabout^2))*tuefri'*tuefri;
beta_ = [ymeanabout; zeros(k-1,1)];
mod2 = minst('nlm', 'beta', 'h', beta_, H_, nu_, s_,
tuefri, y);
nBurn=100;
nIter=10000;
postsim(mod2, nBurn+nIter, 1);
sim2 = postfilter(mod1, [(nBurn+1):(nBurn+nIter)]);
marg2 = mlike(mod2);
bayesfactor = marg1/marg2;
bayesfactor
```

Appendix E. Linear regression postestimation

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

Country	p-value
1) Bulgaria	0.0180
2) Croatia	0.0000
3) Czech Republic	0.3892
4) Estonia	0.0000
5) Hungary	0.2682
6) Latvia	0.0007
7) Lithuania	0.0643
8) Poland	0.0000
9) Romania	0.6839
10) Russia	0.0563
11) Slovakia	0.1133
12) Slovenia	0.0600
13) Ukraine	0.0282

H_0: constant variance

Normality tests

Country	**Shapiro-Walk test**	**Shapiro-Francia test**	**Skewness-kurtosis test**
1) Bulgaria	0.00000	0.00001	0.0000
2) Croatia	0.00000	0.00001	0.0000
3) Czech Republic	0.00000	0.00001	0.00000
4) Estonia	0.00000	0.00001	0.0000
5) Hungary	0.00000	0.00001	0.0000
6) Latvia	0.00000	0.00001	0.0000
7) Lithuania	0.00000	0.00001	0.0000
8) Poland	0.00000	0.00001	0.0000
9) Romania	0.00000	0.00001	0.0000
10) Russia	0.00000	0.00001	0.0000
11) Slovakia	0.0000	0.0001	0.0000
12) Slovenia	0.00000	0.00001	0.0000
13) Ukraine	0.0000	0.0001	0.0000

H_0: non-normal residuals

Arellano-Bond autocorrelation tests

Country	p-value
1) Bulgaria	0.0138
2) Croatia	0.8120
3) Czech Republic	0.0000
4) Estonia	0.0000
5) Hungary	0.00000
6) Latvia	0.00000
7) Lithuania	0.0000
8) Poland	0.0000
9) Romania	0.00000
10) Russia	0.00000
11) Slovakia	0.0001
12) Slovenia	0.0505
13) Ukraine	0.0000

H_0: there is autocorrelation

Appendix F. Alternative estimates.

Simple linear regression with returns being $R_t = \ln(S_t) - \ln(S_{t-1})$

Country	Monday	Tuesday	Friday
1) Bulgaria	-.0023355	-.0007373	.0003236
2) Croatia	-.0016498	.0016798	-.0006833
3) Czech Republic	.0000265	.0009948	.0009338
4) Estonia	-.0008581	.0006127	.0006348
5) Hungary	.0015593	.0006253	.0011584
6) Latvia	-.0009031	.0002555	.0013004
7) Lithuania	-.001258	-.000281	.0004093
8) Poland	.0024138	.0001204	.0016888
9) Romania	-.0014214	-.0001477	.0011194
10) Russia	.0037444*	.0026897	.004446**
11) Slovakia	.0012427	.00126	.001761
12) Slovenia	-.0021	-.0012176	.0009272
13) Ukraine	-.0005906	-.001974	-.0007311

* - significant at 1%, ** - significant at 5%

`reg` with `robust` option enabled in Stata

Country	Monday	Tuesday	Friday
1) Bulgaria	-.0024244	-.0008339	.0002284
2) Croatia	-.0015973	.0016715	-.0007066
3) Czech Republic	.0000183	.0009829	.0009099
4) Estonia	-.0008293	.0006155	.0006407
5) Hungary	.001587	.0006126	.0011461
6) Latvia	-.0008897	.0002359	.0013319
7) Lithuania	-.001248	-.0002781	.0004117
8) Poland	.0025571**	.0002112	.0016868
9) Romania	-.0013879	-.0000692	.0011365
10) Russia	.003762*	.0026567	.0043438**
11) Slovakia	.0012842	.0013233	.0017749**
12) Slovenia	-.0021356	-.001238	.0009181
13) Ukraine	-.0005821	-.002051	-.0007761

* - significant at 1%, ** - significant 5%

`reg` with `robust` option enabled in Stata

Country	Monday	Tuesday	Friday
1) Bulgaria	-.0021356	-.001238	.0009181
2) Croatia	-.0012874	.001872	.000072
3) Czech Republic	.0002143	.0009201	.0009099
4) Estonia	-.0011751	.000501	.0002039
5) Hungary	.0014544	.0009796	.0014499
6) Latvia	-.0003556	.0002359	.0014075
7) Lithuania	-.0010224	-.0004107	.0002816
8) Poland	.0029449**	.0003744	.00126
9) Romania	-.0011515	.0005742	.000935
10) Russia	.0034979*	.0026916	.0040726**
11) Slovakia	.0006616	.0004037	.0014877
12) Slovenia	-.0024099**	-.0019474	.0004234
13) Ukraine	.0000164	-.0015209	-.0004741

* - significant at 1%, ** - significant 5%