Asymmetry in Volatility: A Comparison of Developed and Transition Stock Markets

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Abstract

ARCH modelling framework of Engle (1982) and its GARCH generalization of Bollerslev (1986) gave a huge impetus to econometric model building in the field of financial time series with time-varying variance. The main idea of the models was to describe the most typical features of capital markets like volatility clustering, excess kurtosis and fat tails. As empirical evidence shows asymmetry is also a prominent feature of stock market returns volatility. The reaction of risk if stock returns go off the long run trajectory is different in case of positive and negative market news. Thus it is indispensable to employ asymmetric models being a modification of a traditional GARCH. In the paper we used an approach of Engle and Ng (1993) to test for asymmetric effects in stock indices of developed and Central European stock markets.

JEL-Code: C10, G15.

Keywords: asymmetry, volatility, stock market, transition.

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Introduction

Forecasting volatility of financial returns is important for market agents in portfolio selection and pricing of derivatives. ARCH modelling framework of Engle (1982) and its GARCH generalization of Bollerslev (1986) gave a huge impetus to econometric modelling in the field of financial time series with time-varying variance. The main idea of the models was to describe the most typical features of capital markets like volatility clustering, excess kurtosis and fat tails. There is a comprehensive literature on predictability of asset prices and their volatility (see e.g. Bollerslev et al. 1992).

Since the inception of ARCH and GARCH modelling framework, many modifications of the basic approach were proposed. They are either purely theoretically- or empirically-oriented. In the latter case there is a feedback between academic research and the market itself. Being applied in practice, models affect comprehension of financial processes. All new models seek for a proper specification of conditional volatilities. They are motivated by the studies on the nature of financial markets (see e.g. Black 1976, Christie 1982, French, Schwert and Stambaugh 1987, Schwert 1990, Nelson 1991).

One of the prominent characteristics of financial time series is asymmetry in stock returns volatility. As empirical evidence shows, the reaction of risk if stock returns go off the long run trajectory is different in case of positive and negative market news. A stock market overreaction hypothesis states that the asymmetry property is attributable to mispricing behaviour of investors who appear to consistently overreact to specific market news, especially to bad ones (Liau and Yang 2008).

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Commonly two sorts of asymmetry are distinguished. The first type characterizes directly the distribution of returns: the tendency in the stock markets is that positive returns are dominant while negative ones prevail in their magnitude. The second type of asymmetry relates to non-symmetric reactions of volatility to good and bad news represented by the shocks in financial time series. Despite a clear line between the two definitions of asymmetry, the interconnections in the market do not allow to study the two asymmetric components separately. Asymmetric effects of shocks on volatility mean that dropping stock prices boost the volatility, which, in turn, makes the stock more risky. Higher risk premium is then demanded, translating into subsequent price downswings. Resulting large negative deviations influence the asymmetric shape of the returns distribution (Fiszeder 2001).

The asymmetry has been studied extensively regarding valuation of stocks and derivative instruments (see e.g. Merton 1980, Hull and White 1987, Schwert and Seguin 1990, Baillie and Myers 1991, Ng, Engle and Rothschild 1992). Asymmetric volatility fluctuations can be captured in the specification of the conditional variance. Thus in many cases it is indispensable to employ asymmetric models being a modification of a traditional GARCH.

A unified approach to modelling stock returns in capital markets of emerging and developed countries was subject to some criticism (see e.g. Koutmos, Pericli, Trigeorgis 2006) – there is evidence that, although main patterns stay the same, emerging markets behave in a more unstable manner.

The aim of this paper is to present an analysis of volatility clustering and asymmetry. Bearing in mind the linkages between volatility and returns distributions, we focus on modelling asymmetric effect of shocks on the volatility. A comparative analysis is presented with regard to two groups of stock markets – of developed and transition economies.

In this paper we used two models – GARCH and exponential GARCH (EGARCH). The latter was originally proposed by Nelson (1991). To test for asymmetric effects in stock indices of developed and Central European stock markets we used an approach of Engle and Ng (1993).

The paper is organized as follows. In Section 1 we present the models and testing procedures used throughout the paper. In Section 2 we refer to data issues and introduce preliminary testing to raw data. Section 3 contains testing for asymmetry in GARCH models and final section concludes.

1. The methodology

Let r_t be the rate of return of a stock index in time t. Let F_{t-1} denote an information set of relevant variables up to time $t-1$. The conditional expected value, given F_{t-1}, is defined as $\mu_t = E(r_t \mid F_{t-1})$. The conditional variance of r_t, given F_{t-1}, is defined as $h_t = Var(r_t \mid F_{t-1})$.

The basic $GARCH(p,q)$ model of Bollerslev (1986), being an infinite order ARCH model of Engle (1982) is as follows (see e.g. Davidson and MacKinnon 2003):

$$r_t = \mu_t + u_t, \tag{1}$$

$$u_t = \sqrt{h_t}\varepsilon_t, \; h_t \equiv E(u_t^2 \mid F_{t-1}), \tag{2}$$

$$h_t = \omega + \sum_{i=1}^{q} \alpha_i u_{t-i}^2 + \sum_{j=1}^{p} \delta_j h_{t-j}, \tag{3}$$

where ω, α_i and δ_j are constant parameters and $\varepsilon_t \sim N(0,1)$. In the GARCH model the news impact curve (Engle and Ng 1993), i.e. the function that relates past return shocks (unexpected returns) to current volatility is a quadratic function centered at $\varepsilon_{t-1} = 0$. Hence, positive and negative $u's$ of equal size have the same impact on volatility. If asymmetry is an important feature of returns volatility, an alternative model should be used. Within the ARCH family there are many competing models designated to capture asymmetry in volatility, with EGARCH and GJR (Glosten, Jagannathan and Runkle 1993) specifications being most commonly used in the literature. The main difference between the two approaches is whether the reaction of volatility to market news is quadratic (GJR) or exponential (EGARCH). As the aim of our paper is not to test one specification versus another, basing on some recent empirical results, we employed an EGARCH model for asymmetry analysis (Dima, Haim and Rami 2008, McAleer 2007).

The EGARCH model is given as follows (Nelson 1991):

$$r_t = \mu_t + u_t, \tag{4}$$

$$u_t = \sqrt{h_t}\varepsilon_t,\ h_t \equiv E(u_t^2 \left| F_{t-1}\right.), \tag{5}$$

$$\log(h_t) = \omega + \beta \log(h_{t-1}) + \gamma \frac{u_{t-1}}{\sqrt{h_{t-1}}} + \alpha \left[\frac{\left|u_{t-1}\right|}{\sqrt{h_{t-1}}} - \sqrt{\frac{2}{\pi}} \right], \tag{6}$$

where ω, β, γ and α are constant parameters and $\varepsilon_t \sim N(0,1)$. In the EGARCH model the news impact curve is an exponential function. It has a minimum at $\varepsilon_{t-1} = 0$ and is increasing in both directions but with different parameters. Hence it captures asymmetric behavior of time series as it allows positive and negative unexpected returns to have a different impact on volatility. The advantage of EGARCH methodology is that it facilitates a simultaneous investigation of the asymmetric impact of positive and negative news on stock returns volatility (Verma and Jackson 2008). Furthermore, the specification of conditional variance captures the size effects as it allows excess unexpected returns to have a greater impact on volatility.

For a comparative analysis we will use a standard GARCH model followed by an EGARCH approach within three specifications of the conditional mean μ. They are the following:

$$r_t = a + u_t, \tag{7}$$

$$r_t = b_0 + b_1 r_{t-1} + u_t, \tag{8}$$

$$r_t = c_0 + c_1 \overline{r}_{t-s} + u_t, \tag{9}$$

where: a, b_0, b_1, c_0, c_1 are constant parameters, $\overline{r}_{t-s}$ is a return on Dow Jones index, $s \geq 0$. Equation (9) is a stylized single-index Sharpe model.

To accommodate the potential asymmetry in volatility of returns on stock indices which is not captured by the underlying models we used the conditional variance misspecification tests of Engle and Ng (1993).

The diagnostic tests, the Sign Bias Test (SBT), the Negative Size Bias Test (NSBT), the Positive Size Bias Test (PSBT) and the joint test examine whether the squared normalized residual ε_t can be predicted with additional variables not explicitly included in a particular conditional volatility function.

Let $\varepsilon_t = u_t / \sqrt{h_t}$ be the normalized residual which corresponds to a particular volatility model. The SBT considers a dummy variable S_{t-1}^- that takes a value of one when $u_{t-1} < 0$ and zero otherwise. The NSBT uses the variable $S_{t-1}^- u_{t-1}$. The PSBT utilizes the variable $S_{t-1}^+ u_{t-1}$ where S_{t-1}^+ is defined as $1 - S_{t-1}^-$. Hence the testing regressions are given respectively:

$$\varepsilon_t^2 = \theta_0 + \theta_1 S_{t-1}^- + \xi_t , \tag{10}$$

$$\varepsilon_t^2 = \theta_0 + \theta_1 S_{t-1}^- u_{t-1} + \xi_t , \tag{11}$$

$$\varepsilon_t^2 = \theta_0 + \theta_1 S_{t-1}^+ u_{t-1} + \xi_t , \tag{12}$$

where $\theta's$ are constant parameters and ξ denotes the residual. The tests can be conducted jointly as follows:

$$\varepsilon_t^2 = \theta_0 + \theta_1 S_{t-1}^- + \theta_2 S_{t-1}^- u_{t-1} + \theta_3 S_{t-1}^+ u_{t-1} + \xi_t , \tag{13}$$

where θ_i, $i = 0,\ldots,3$ are constant coefficients and ξ is the residual. If the volatility model being used is correct, then $\theta_i = 0$, $i = 1,2,3$ and ξ is i.i.d. The tests are the LM tests and the statistics follow a $\chi^2(1)$ distribution in (10)-(12) and $\chi^2(3)$ in (13).

2. The data and preliminary testing

In the research we used the data on daily close-to-close logarithmic returns $r_t \equiv 100(\log y_t - \log y_{t-1})$ for six indices of developed and six of transition economies, namely:

- Canada – TSX,
- France – CAC40,
- Germany – DAX,

- Italy – MIBTEL,
- United Kingdom – FTSE100,
- Japan – NIKKEI225,
- Hungary – BUX,
- Poland – WIG20,
- Russia – RTS,
- Slovakia – SAX,
- Slovenia – SBI20,
- Baltic Republics (Estonia, Latvia, Lithuania) – OMXBGI.

The sample starts at the beginning of 2005 and ends at the beginning of 2008. Due to the financial crisis of the year 2008 and resulting substantial instability in capital markets, inclusion of this year into the sample might have a strong impact on our results. We leave performance of presented methods in times of instability as an issue for further research.

In Tab. 1 we presented basic descriptive statistics of the time series. There is a clear difference between the two groups of countries with respect to central tendency measures and measures of dispersion. Mean returns in Central European economies (CEE) are generally higher which is followed by also higher standard deviations. There is a clear economic interpretation saying that for investing in more risky markets we get higher return with high volatility being the cost. Without an exception, index returns are leptokurtic and exhibit asymmetry to the left, which depicts typical aspects of investing in capital markets. There is a noticeable difference in magnitude of coefficients of asymmetry between the two surveyed groups of countries. In transition economies these coefficients tend to have slightly lower values. Through the relations between asymmetric character of volatility and asymmetry of returns probability distributions, this may suggest that different approaches are required to model conditional variance in the two groups of markets. Jarque-Bera statistics show significant departures from a normal distribution, being also an evidence of outliers and fat tails. Ljung-Box (LB) test conducted on return levels and squares suggests a strong presence of serial correlation. This is especially the case of squared returns giving a first evidence of conditional heteroskedasticity.

The diagnostic misspecification tests given in the previous section can also be applied to raw data without first imposing a conditional volatility model. Such approach allows for a quick overview of the data before deciding on the more complex machinery to be employed. Given the properties of these diagnostic tests however, they should be treated as preliminary summary statistics rather than final tests of asymmetry (Engle and Ng 1993).

Let $u_t \equiv r_t - \mu$ and $\varepsilon_t \equiv u_t / \sigma$, where μ and σ are the unconditional mean and standard deviation of r_t, respectively. Tab. 2 presents the results of the tests. As NSB test shows, stock returns seem sensitive to lagged values which are lower than the mean. Both individual and joint tests with low probability values detected asymmetry in many cases, giving an incentive to employ asymmetric models framework. However, interpretation of the tests depends on properties of residuals from conducted regressions. Diagnostic tests, namely a Ljung-Box test with 10 lags and a White test, indicate the presence of serial correlation and, in some cases, heteroskedasticity in these residuals. In this case the tests may be biased, which calls for a careful interpretation of the results.

	Mean (%)	Median (%)	Max (%)	Min (%)	St. dev. (pp)	Skew.	Kurtosis
BUX	0,06	0,08	4,87	-5,38	1,41	-0,16	3,90
OMX	0,08	0,10	6,06	-4,44	0,78	0,00	15,85
RTS	0,22	0,26	6,53	-5,87	1,51	-0,23	4,91
SAX	0,06	0,02	4,07	-4,67	0,97	-0,29	7,98
SBI	0,14	0,05	4,56	-3,17	0,80	0,14	7,30
WIG	0,05	0,05	4,76	-4,63	1,41	-0,12	3,73
CAC	0,06	0,12	3,22	-3,31	0,94	-0,44	4,08
DAX	0,08	0,15	2,61	-3,46	0,94	-0,38	3,67
FTSE	0,05	0,08	3,44	-4,19	0,87	-0,47	5,82
MIBTEL	0,04	0,10	2,15	-3,25	0,77	-0,64	4,38
NIKKEI	0,03	0,01	3,60	-5,57	1,09	-0,26	4,88
TSX	0,04	0,07	2,16	-2,80	0,81	-0,56	3,67
DJ	0,02	0,08	2,78	-3,30	0,86	-0,42	4,09

	J-B	p-value	LB(10) levels	p-value	LB(10) squares	p-value	No. obs.
BUX	22,56	0,00	40,74	0,00	210,47	0,00	565
OMX	3983,30	0,00	52,36	0,00	48,60	0,00	579
RTS	88,64	0,00	12,43	0,26	188,37	0,00	550
SAX	564,96	0,00	12,80	0,24	75,84	0,00	540
SBI	427,13	0,00	36,80	0,00	167,54	0,00	551
WIG	13,77	0,00	4,06	0,95	66,32	0,00	557
CAC	47,43	0,00	16,58	0,08	181,48	0,00	583
DAX	24,95	0,00	16,76	0,08	93,24	0,00	583
FTSE	212,49	0,00	13,37	0,20	268,14	0,00	578
MIBTEL	84,15	0,00	19,52	0,03	96,37	0,00	570
NIKKEI	86,91	0,00	17,56	0,06	90,85	0,00	551
TSX	37,45	0,00	7,57	0,67	43,20	0,00	530
DJ	46,08	0,00	10,97	0,36	131,93	0,00	583

Tab. 1. Descriptive statistics

	SB	p-value	White	p-value	LB(10)	p-value
BUX	2,97	0,09	1,75	0,19	54,48	0,00
OMX	3,95	0,05	2,23	0,14	53,75	0,00
RTS	2,62	0,11	0,50	0,48	188,79	0,00
SAX	1,56	0,21	0,22	0,64	66,34	0,00
SBI	0,01	0,92	1,13	0,29	167,77	0,00
WIG	0,02	0,88	0,10	0,75	65,73	0,00
CAC	0,28	0,60	0,21	0,65	163,61	0,00
DAX	2,15	0,14	0,36	0,55	91,74	0,00
FTSE	1,96	0,16	2,76	0,10	263,50	0,00
MIBTEL	2,41	0,12	0,00	0,95	92,56	0,00
NIKKEI	1,45	0,23	0,29	0,59	90,15	0,00
TSX	0,08	0,77	0,12	0,73	42,74	0,00
	PSB	p-value	White	p-value	LB(10)	p-value
BUX	7,98	0,00	1,38	0,24	37,38	0,00
OMX	20,66	0,00	0,83	0,36	25,74	0,00
RTS	15,47	0,00	10,20	0,00	130,96	0,00
SAX	0,56	0,45	0,08	0,78	66,06	0,00
SBI	55,34	0,00	32,08	0,00	86,58	0,00
WIG	0,00	0,96	0,35	0,55	66,14	0,00
CAC	5,18	0,02	0,87	0,35	143,77	0,00
DAX	5,26	0,02	0,13	0,72	75,10	0,00
FTSE	29,40	0,00	14,74	0,00	156,03	0,00
MIBTEL	4,73	0,03	0,61	0,44	77,50	0,00
NIKKEI	3,72	0,05	4,30	0,04	77,73	0,00
TSX	0,46	0,50	0,12	0,73	40,67	0,00
	NSB	p-value	White	p-value	LB(10)	p-value
BUX	0,01	0,94	0,15	0,70	56,15	0,00
OMX	0,47	0,49	1,60	0,21	58,53	0,00
RTS	2,68	0,10	4,61	0,03	171,56	0,00
SAX	5,77	0,02	1,08	0,30	46,38	0,00
SBI	7,81	0,01	0,11	0,74	112,20	0,00
WIG	0,70	0,40	1,11	0,29	66,42	0,00
CAC	0,25	0,62	1,20	0,27	171,88	0,00
DAX	0,13	0,72	0,59	0,44	95,82	0,00
FTSE	0,18	0,67	1,63	0,20	252,15	0,00
MIBTEL	0,17	0,68	1,05	0,30	93,32	0,00
NIKKEI	0,18	0,67	0,02	0,89	93,32	0,00
TSX	1,08	0,30	0,29	0,59	45,39	0,00
	Joint test	p-value	White	p-value	LB(10)	p-value
BUX	10,58	0,00	3,30	0,65	33,21	0,00
OMX	20,84	0,00	4,14	0,53	24,28	0,01
RTS	27,01	0,00	18,75	0,00	90,51	0,00
SAX	7,89	0,05	1,80	0,88	41,45	0,00
SBI	87,24	0,00	31,42	0,00	29,60	0,00
WIG	1,03	0,79	1,37	0,93	68,93	0,00
CAC	7,65	0,05	4,63	0,46	119,83	0,00
DAX	5,78	0,12	0,59	0,99	70,13	0,00
FTSE	37,05	0,00	14,18	0,01	110,94	0,00
MIBTEL	5,42	0,14	4,67	0,46	74,04	0,00
NIKKEI	3,93	0,27	6,15	0,29	75,52	0,00
TSX	1,83	0,61	2,27	0,81	44,42	0,00

Tab. 2. Preliminary asymmetry tests

3. Testing for asymmetry in stock returns volatility

Having considered the three specifications of the conditional mean, we applied an ARCH test to residuals u_t (Tab. 3). ARCH effects seem to be strongly present in residuals. There is, however, one exception: the TSX index in the Sharpe model. This gives evidence that ARCH effects might be not invariant against a form of the mean specification. The TSX index was the one of special interest as the ARCH tests results suggest that a linear combination of two ARCH processes may produce a random variable free from conditional heteroskedasticity. Residuals from mean equations in this simple form show also serial correlation, which is another signal of misspecification.

	CONST		AR(1)			SHARPE		
	a	ARCH test	b_0	b_1	ARCH test	c_0	c_1	ARCH test
BUX	0,00	33,84	0,00	0,05	33,48	0,00	0,05	33,48
	0,29	0,00	0,33	0,25	0,00	0,33	0,25	0,00
OMX	0,00	36,83	0,00	0,16	37,80	0,00	0,22	31,99
	0,01	0,00	0,04	0,00	0,00	0,02	0,00	0,00
RTS	0,00	81,09	0,00	0,04	79,88	0,00	0,39	74,71
	0,00	0,00	0,00	0,30	0,00	0,00	0,00	0,00
SAX	0,00	48,60	0,00	0,08	48,99	0,00	0,02	49,83
	0,16	0,00	0,21	0,07	0,00	0,18	0,62	0,00
SBI	0,00	94,53	0,00	0,16	69,93	0,00	0,15	92,43
	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
WIG	0,00	60,10	0,00	-0,01	59,70	0,00	0,23	54,81
	0,44	0,00	0,42	0,88	0,00	0,46	0,00	0,00
CAC	0,00	82,16	0,00	-0,05	82,75	0,00	0,22	95,26
	0,10	0,00	0,09	0,24	0,00	0,12	0,00	0,00
DAX	0,00	51,03	0,00	-0,01	51,05	0,00	0,24	50,68
	0,04	0,00	0,04	0,89	0,00	0,05	0,00	0,00
FTSE	0,00	103,87	0,00	-0,08	106,64	0,00	0,19	103,37
	0,21	0,00	0,16	0,04	0,00	0,24	0,00	0,00
MIBTEL	0,00	54,83	0,00	0,00	54,84	0,00	0,17	60,89
	0,23	0,00	0,23	0,92	0,00	0,26	0,00	0,00
NIKKEI	0,00	52,88	0,00	-0,02	51,35	0,00	0,44	41,61
	0,52	0,00	0,49	0,59	0,00	0,50	0,00	0,00
TSX	0,00	30,40	0,00	-0,04	29,06	0,00	0,63	10,78
	0,24	0,00	0,20	0,35	0,00	0,21	0,00	0,37

Tab. 3. Mean equations and ARCH tests

Having conducted ARCH tests, we moved to estimation of GARCH(1,1) and EGARCH(1,1) models for the three models of the conditional mean (7)-(9). Tab. 4 gives details of the GARCH fit. From three mean specifications, we obtained best estimates in the stylized Sharpe model. Parameters on DJCA index are significant in most cases, in both groups of countries. As we can see, the country betas (risk) were much below one with an exception of TSX index (0.63). Hence all stock markets appeared to be defensive in terms of the American market. There were clear spillover effects of the US market into other markets with stronger effects for developed economies.

The models are consistent with the results of ARCH tests described above. In all cases, parameters α and δ (or at last δ alone) are statistically significant, indicating dependence of volatility on squared past deviations from the mean. Comparison of the three approaches to GARCH modelling (7)-(9) shows that the estimates obtained for the conditional variance equation are not invariant against the form of the mean specification. The variant with a systematic factor of the DJCA index gives a bit lower α's. This may be an argument for a systematic approach to mean specification allowing for separation of spillover effects of US market from volatility clustering effects (Chen et al. 2006).

Basic diagnostic tests show that with GARCH specification we eliminated serial correlation, conditional and unconditional heteroskedasticity from residuals. Consecutively, we applied the four volatility misspecification tests on normalized residuals of the particular volatility model.

Misspecification test results are given in Tab. 5. The parameters on additional variables we test are, in most cases, not statistically significant, which suggests that GARCH model performed reasonably well in describing volatile processes in the studied markets. Consequently, including asymmetric variables under question would not bring much change to the goodness of fit. However, there are a few cases in which we can see statistical significance of additional variables at 10% level of significance, which accommodate news size effects. This gives an incentive to build asymmetric models for comparison.

	CONST				AR(1)					SHARPE				
	a	ω	α	δ	b_0	b_1	ω	α	δ	c_0	c_1	ω	α	δ
BUX	0,00	0,00	0,12	0,78	0,00	0,03	0,00	0,11	0,78	0,00	0,03	0,00	0,11	0,78
	0,03	0,02	0,00	0,00	0,04	0,47	0,02	0,00	0,00	0,04	0,47	0,02	0,00	0,00
OMX	0,00	0,00	0,26	0,82	0,00	0,25	0,00	0,27	0,82	0,00	0,09	0,00	0,26	0,82
	0,14	0,26	0,00	0,00	0,21	0,00	0,22	0,00	0,00	0,21	0,00	0,16	0,00	0,00
RTS	0,00	0,00	0,13	0,79	0,00	0,02	0,00	0,13	0,79	0,00	0,30	0,00	0,12	0,79
	0,00	0,01	0,00	0,00	0,00	0,71	0,01	0,00	0,00	0,00	0,00	0,01	0,00	0,00
SAX	0,00	0,00	0,10	0,86	0,00	0,00	0,00	0,10	0,85	0,00	0,00	0,00	0,10	0,85
	0,48	0,00	0,00	0,00	0,47	0,97	0,00	0,00	0,00	0,48	0,98	0,00	0,00	0,00
SBI	0,00	0,00	0,31	0,63	0,00	0,17	0,00	0,30	0,62	0,00	0,07	0,00	0,29	0,64
	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,00	0,00	0,00
WIG	0,00	0,00	0,05	0,92	0,00	0,00	0,00	0,06	0,91	0,00	0,27	0,00	0,05	0,93
	0,35	0,13	0,03	0,00	0,33	0,94	0,15	0,02	0,00	0,40	0,00	0,15	0,03	0,00
CAC	0,00	0,00	0,08	0,88	0,00	-0,08	0,00	0,08	0,87	0,00	0,23	0,00	0,07	0,90
	0,04	0,06	0,00	0,00	0,02	0,10	0,05	0,00	0,00	0,05	0,00	0,09	0,00	0,00
DAX	0,00	0,00	0,09	0,85	0,00	-0,04	0,00	0,09	0,85	0,00	0,23	0,00	0,08	0,86
	0,01	0,04	0,00	0,00	0,01	0,39	0,03	0,00	0,00	0,02	0,00	0,05	0,00	0,00
FTSE	0,00	0,00	0,16	0,81	0,00	-0,09	0,00	0,15	0,82	0,00	0,17	0,00	0,15	0,82
	0,07	0,03	0,00	0,00	0,03	0,06	0,03	0,00	0,00	0,09	0,00	0,03	0,00	0,00
MIBTEL	0,00	0,00	0,09	0,84	0,00	-0,05	0,00	0,09	0,84	0,00	0,18	0,00	0,08	0,85
	0,07	0,03	0,01	0,00	0,05	0,32	0,03	0,01	0,00	0,11	0,00	0,04	0,01	0,00
NIKKEI	0,00	0,00	0,11	0,87	0,00	0,00	0,00	0,11	0,87	0,00	0,36	0,00	0,11	0,88
	0,20	0,05	0,00	0,00	0,18	0,99	0,05	0,00	0,00	0,16	0,00	0,08	0,00	0,00
TSX	0,00	0,00	0,05	0,86	0,00	-0,02	0,00	0,05	0,87	0,00	0,64	0,00	0,01	0,96
	0,24	0,21	0,06	0,00	0,22	0,76	0,23	0,06	0,00	0,27	0,00	0,17	0,23	0,00

Tab. 4. GARCH model estimates

CONST

	SB	p-value	White	p-value	LB(10)	p-value	NSB	p-value	White	p-value	LB(10)	p-value	PSB	p-value	White	p-value	LB(10)	p-value	Joint	p-value	White	p-value	LB(10)	p-value
BUX	4,84	0,03	5,08	0,02	3,73	0,96	0,91	0,34	1,26	0,26	3,77	0,96	2,34	0,13	2,70	0,10	3,61	0,96	5,23	0,16	7,04	0,22	3,66	0,96
OMX	0,29	0,59	0,77	0,38	1,91	1,00	0,17	0,68	0,42	0,51	1,78	1,00	2,09	0,15	0,76	0,38	1,76	1,00	4,16	0,24	4,26	0,51	2,41	0,99
RTS	1,48	0,22	0,03	0,85	5,46	0,86	1,68	0,19	1,20	0,27	5,55	0,85	0,94	0,33	0,65	0,42	5,84	0,83	2,07	0,56	2,13	0,83	5,68	0,84
SAX	1,21	0,27	0,01	0,92	5,00	0,89	0,51	0,47	0,69	0,41	4,59	0,92	0,00	0,97	0,51	0,47	5,09	0,89	1,80	0,61	2,05	0,84	4,45	0,93
SBI	0,36	0,55	0,93	0,33	3,96	0,95	0,35	0,55	0,34	0,56	3,96	0,95	0,22	0,64	0,60	0,44	4,09	0,94	0,49	0,92	1,25	0,94	3,90	0,95
WIG	0,10	0,76	0,17	0,68	22,61	0,01	0,43	0,51	0,47	0,49	22,48	0,01	3,12	0,08	1,54	0,21	19,53	0,03	5,68	0,13	2,41	0,79	20,20	0,03
CAC	0,79	0,37	0,60	0,44	10,08	0,43	0,06	0,80	0,34	0,56	9,95	0,45	2,35	0,13	0,64	0,42	9,66	0,47	2,51	0,47	6,32	0,28	9,49	0,49
DAX	2,03	0,15	0,04	0,83	11,47	0,32	0,41	0,52	0,38	0,54	11,79	0,30	3,50	0,06	0,99	0,32	10,97	0,36	3,72	0,29	3,19	0,67	10,96	0,36
FTSE	0,97	0,32	0,02	0,89	13,70	0,19	1,31	0,25	0,50	0,48	15,44	0,12	3,36	0,07	1,04	0,31	13,33	0,21	3,88	0,27	3,85	0,57	13,93	0,18
MIBTEL	2,35	0,13	0,17	0,68	10,40	0,41	0,43	0,51	0,11	0,74	10,85	0,37	3,16	0,08	1,35	0,25	9,95	0,45	3,51	0,32	6,52	0,26	9,80	0,46
NIKKEI	3,51	0,06	1,55	0,21	15,03	0,13	0,63	0,43	3,85	0,05	16,40	0,09	6,12	0,01	1,73	0,19	12,66	0,24	6,37	0,09	4,25	0,51	12,23	0,27
TSX	0,05	0,82	0,30	0,59	7,95	0,63	0,01	0,91	0,39	0,53	7,77	0,65	3,18	0,07	0,93	0,33	7,39	0,69	5,21	0,16	4,94	0,42	7,31	0,70

AR(1)

	SB	p-value	White	p-value	LB(10)	p-value	NSB	p-value	White	p-value	LB(10)	p-value	PSB	p-value	White	p-value	LB(10)	p-value	Joint	p-value	White	p-value	LB(10)	p-value
BUX	4,81	0,03	4,93	0,03	3,82	0,96	0,74	0,39	1,02	0,31	3,87	0,95	2,25	0,13	2,67	0,10	3,62	0,96	5,34	0,15	7,22	0,20	3,69	0,96
OMX	1,60	0,21	1,33	0,25	1,49	1,00	0,22	0,64	0,25	0,62	1,50	1,00	1,84	0,17	0,71	0,40	1,37	1,00	3,88	0,27	3,96	0,56	1,28	1,00
RTS	1,39	0,24	0,03	0,86	5,29	0,87	1,51	0,22	1,08	0,30	5,41	0,86	0,92	0,34	0,62	0,43	5,69	0,84	1,90	0,59	1,94	0,86	5,53	0,85
SAX	1,46	0,23	0,03	0,86	4,51	0,92	0,58	0,45	0,73	0,39	4,08	0,94	0,00	0,97	0,49	0,48	4,64	0,91	2,13	0,55	2,12	0,83	3,88	0,95
SBI	0,18	0,68	0,97	0,32	4,12	0,94	0,16	0,69	0,08	0,78	4,18	0,94	0,17	0,68	0,55	0,46	4,20	0,94	0,26	0,97	1,90	0,86	4,14	0,94
WIG	0,05	0,82	0,13	0,72	23,15	0,01	0,48	0,49	0,47	0,49	22,98	0,01	2,97	0,08	1,50	0,22	20,06	0,03	7,53	0,06	2,37	0,80	20,94	0,02
CAC	0,43	0,51	0,51	0,48	11,08	0,35	0,13	0,71	0,24	0,63	11,26	0,34	2,98	0,08	0,98	0,32	11,04	0,35	3,42	0,33	7,46	0,19	10,88	0,37
DAX	1,40	0,24	0,04	0,83	12,54	0,25	0,46	0,50	0,33	0,56	12,96	0,23	3,30	0,07	0,96	0,33	12,25	0,27	3,29	0,35	3,36	0,65	12,25	0,27
FTSE	3,39	0,07	0,42	0,52	15,32	0,12	1,80	0,18	1,40	0,24	17,49	0,06	3,99	0,05	1,40	0,24	15,13	0,13	4,64	0,20	2,45	0,78	15,25	0,12
MIBTEL	1,87	0,17	0,16	0,69	10,51	0,40	0,54	0,46	0,09	0,77	11,00	0,36	3,38	0,07	1,25	0,26	10,10	0,43	3,42	0,33	6,21	0,29	10,09	0,43
NIKKEI	3,59	0,06	1,58	0,21	15,00	0,13	0,65	0,42	3,89	0,05	16,40	0,09	6,20	0,01	1,74	0,19	12,62	0,25	6,45	0,09	4,28	0,51	12,20	0,27
TSX	0,03	0,86	0,09	0,77	7,60	0,67	0,02	0,88	0,09	0,76	7,21	0,62	3,17	0,07	0,38	0,54	7,07	0,72	1,93	0,59	2,38	0,79	45,45	0,00

SHARPE

	SB	p-value	White	p-value	LB(10)	p-value	NSB	p-value	White	p-value	LB(10)	p-value	PSB	p-value	White	p-value	LB(10)	p-value	Joint	p-value	White	p-value	LB(10)	p-value
BUX	4,81	0,03	4,93	0,03	3,82	0,96	0,74	0,39	1,02	0,31	3,87	0,95	2,25	0,13	2,67	0,10	3,62	0,96	5,34	0,15	7,22	0,20	3,69	0,96
OMX	0,05	0,82	0,67	0,41	1,80	1,00	0,12	0,73	0,41	0,52	1,72	1,00	1,80	0,18	0,43	0,51	1,77	1,00	2,92	0,40	3,11	0,68	2,18	1,00
RTS	0,66	0,42	0,13	0,72	6,55	0,77	0,83	0,36	0,70	0,40	6,97	0,73	0,36	0,55	0,50	0,48	6,53	0,77	0,96	0,81	2,08	0,84	6,90	0,74
SAX	1,34	0,25	0,03	0,86	4,54	0,92	0,58	0,45	0,73	0,39	4,08	0,94	0,00	0,97	0,49	0,48	4,65	0,91	1,99	0,58	2,13	0,83	3,91	0,95
SBI	0,28	0,60	0,94	0,33	4,01	0,95	0,50	0,48	0,33	0,56	3,87	0,95	0,17	0,68	0,58	0,45	4,10	0,94	0,55	0,91	1,22	0,94	3,86	0,95
WIG	0,25	0,62	0,18	0,67	21,01	0,02	0,50	0,48	0,55	0,46	19,65	0,03	2,92	0,09	1,62	0,20	17,12	0,07	7,53	0,06	6,46	0,26	18,39	0,05
CAC	0,02	0,89	1,35	0,25	8,82	0,55	0,06	0,81	0,75	0,39	8,48	0,58	0,64	0,42	0,47	0,49	8,59	0,57	1,51	0,68	3,93	0,56	8,12	0,62
DAX	0,33	0,57	0,04	0,83	8,71	0,56	0,03	0,85	0,81	0,37	8,87	0,55	1,89	0,17	0,96	0,33	7,88	0,64	2,12	0,55	5,51	0,36	7,55	0,67
FTSE	0,48	0,49	0,21	0,65	8,88	0,54	0,48	0,49	0,07	0,79	9,88	0,45	1,82	0,18	0,45	0,50	8,49	0,58	1,97	0,58	1,52	0,91	8,83	0,55
MIBTEL	1,14	0,28	0,45	0,50	9,32	0,50	0,01	0,94	0,54	0,46	8,72	0,56	1,87	0,17	0,63	0,43	8,45	0,59	2,37	0,50	6,22	0,29	8,12	0,62
NIKKEI	0,76	0,38	0,58	0,45	6,01	0,82	0,42	0,52	2,91	0,09	6,65	0,76	4,03	0,04	0,55	0,46	4,33	0,93	4,34	0,23	3,50	0,62	3,87	0,95
TSX	0,00	0,96	0,01	0,91	10,13	0,43	0,02	0,89	0,38	0,54	10,13	0,43	0,01	0,93	0,28	0,59	10,11	0,43	0,03	1,00	2,24	0,82	10,09	0,43

Tab. 5. Misspecification tests applied to GARCH residuals

Tab. 6 gives the estimation results of the EGARCH specification. A parameter responsible for asymmetry is γ. In most cases it is negative. Stronger effects can be seen in developed countries. For the TSX again it seems that all predictable effects were already included in the DJCA index. The asymmetric behaviour of returns volatility in transition countries was not that typical. EGARCH specification seems to model best the BUX index. For the RTS and SBI, parameters significance in the conditional variance equation varies depending on the mean specification. Sharpe model seems reasonable for Moscow index, while AR(1) model gives the best fit for SBI. Based on 10% significance level, it is possible that there are some asymmetric effects. However, they may be more difficult to capture in the form of an EGARCH model. Other three indices, WIG20, SAX and OMX probably exhibit no typical asymmetry, as γ parameters are either not significant or have the positive sign. However, for the SAX the problem may be with a good specification of the mean, which affects conditional variance equation. Another solution would be employing a different asymmetric models (see e.g. Hansson and Hördahl 2005 for VS-GARCH model of the OMX index and Miłobędzki 2006 for different asymmetric models of the WIG index). Additionally, some improvements could be possibly achieved by adopting more realistic assumptions about the error probability distribution prior to the specification of GARCH or EGARCH models.

Generally γ's are rather low, their absolute value fluctuates around 0.1. This means that other elements like specification of the mean and GARCH effects take the bulk of explaining the process of stock returns. This is also consistent with misspecification tests results related to the GARCH fit, saying that the GARCH models performed reasonably well.

Misspecification tests applied to the EGARCH models (Tab. 7) indicate that inclusion of additional asymmetric variables to the conditional variance equation would not bring any extra information. In comparison to tests conducted on GARCH residuals, higher p-values mean that asymmetric approach produced better results and the relevance of γ estimates is thus supported.

	CONST					AR(1)						SHARPE					
	a	ω	α	γ	β	b_0	b_1	ω	α	γ	β	c_0	c_1	ω	α	γ	β
BUX	0,00	-1,46	0,23	-0,08	0,85	0,00	0,03	-1,43	0,23	-0,08	0,85	0,00	0,03	-1,43	0,23	-0,08	0,85
	0,08	0,00	0,00	0,01	0,00	0,11	0,44	0,00	0,00	0,01	0,00	0,11	0,44	0,00	0,00	0,01	0,00
OMX	0,00	-0,32	0,28	0,02	0,99	0,00	0,20	-0,35	0,30	0,03	0,98	0,00	0,09	-0,36	0,28	0,03	0,98
	0,00	0,00	0,00	0,05	0,00	0,01	0,00	0,00	0,00	0,03	0,00	0,01	0,00	0,00	0,00	0,02	0,00
RTS	0,00	-0,91	0,24	-0,04	0,91	0,00	0,00	-0,93	0,24	-0,04	0,91	0,00	0,30	-0,97	0,23	-0,05	0,91
	0,00	0,00	0,00	0,14	0,00	0,00	0,95	0,00	0,00	0,14	0,00	0,00	0,00	0,00	0,00	0,10	0,00
SAX	0,00	-0,77	0,21	0,04	0,93	0,00	0,00	-0,87	0,24	0,05	0,92	0,00	0,00	-0,85	0,23	0,04	0,93
	1,00	0,00	0,00	0,09	0,00	0,96	0,96	0,00	0,00	0,08	0,00	1,00	1,00	0,00	0,00	0,09	0,00
SBI	0,00	-2,09	0,62	-0,07	0,84	0,00	0,14	-2,15	0,60	-0,08	0,83	0,00	0,06	-2,05	0,59	-0,06	0,84
	0,00	0,00	0,00	0,08	0,00	0,00	0,00	0,00	0,00	0,04	0,00	0,00	0,03	0,00	0,00	0,13	0,00
WIG	0,00	-8,52	-0,12	-0,05	-0,01	0,00	-0,01	-8,73	-0,12	-0,05	-0,03	0,00	0,24	-15,92	-0,14	0,01	-0,87
	0,46	0,15	0,22	0,42	0,99	0,43	0,81	0,15	0,23	0,43	0,96	0,39	0,00	0,00	0,03	0,73	0,00
CAC	0,00	-0,49	0,10	-0,12	0,96	0,00	-0,08	-0,53	0,11	-0,12	0,95	0,00	0,22	-0,46	0,10	-0,12	0,96
	0,21	0,00	0,00	0,00	0,00	0,13	0,09	0,00	0,00	0,00	0,00	0,31	0,00	0,01	0,00	0,00	0,00
DAX	0,00	-0,81	0,13	-0,12	0,93	0,00	-0,02	-0,85	0,14	-0,12	0,92	0,00	0,24	-0,81	0,13	-0,12	0,93
	0,07	0,00	0,00	0,00	0,00	0,05	0,66	0,00	0,00	0,00	0,00	0,12	0,00	0,01	0,01	0,00	0,00
FTSE	0,00	-0,46	0,22	-0,11	0,97	0,00	-0,08	-0,45	0,21	-0,10	0,97	0,00	0,15	-0,44	0,21	-0,10	0,97
	0,55	0,00	0,00	0,00	0,00	0,26	0,07	0,00	0,00	0,00	0,00	0,68	0,00	0,00	0,00	0,00	0,00
MIBTEL	0,00	-0,65	0,07	-0,14	0,94	0,00	-0,05	-0,67	0,08	-0,14	0,94	0,00	0,16	-0,58	0,07	-0,13	0,95
	0,41	0,00	0,12	0,00	0,00	0,32	0,33	0,00	0,10	0,00	0,00	0,47	0,00	0,01	0,11	0,00	0,00
NIKKEI	0,00	-0,47	0,19	-0,08	0,96	0,00	0,01	-0,47	0,19	-0,08	0,96	0,00	0,37	-0,47	0,21	-0,09	0,97
	0,71	0,00	0,00	0,00	0,00	0,64	0,77	0,00	0,00	0,00	0,00	0,61	0,00	0,00	0,00	0,00	0,00
TSX	0,00	-0,95	0,08	-0,08	0,91	0,00	-0,01	-1,48	0,01	-0,09	0,85	0,00	0,62	-18,97	0,14	0,02	-0,84
	0,48	0,14	0,13	0,01	0,00	0,32	0,81	0,00	0,73	0,01	0,00	0,29	0,00	0,00	0,03	0,56	0,00

Tab. 6. EGARCH models estimates

CONST

	SB	p-value	White	p-value	LB(10)	p-value	NSB	p-value	White	p-value	LB(10)	p-value	PSB	p-value	White	p-value	LB(10)	p-value	Joint	p-value	White	p-value	LB(10)	p-value
BUX	0,66	0,42	0,82	0,37	6,69	0,75	0,11	0,74	0,37	0,55	6,39	0,78	0,13	0,72	0,25	0,62	6,51	0,77	1,96	0,58	4,55	0,47	6,89	0,74
OMX	2,16	0,14	1,36	0,24	1,68	1,00	0,26	0,61	0,27	0,60	1,79	1,00	2,05	0,15	0,91	0,34	2,18	1,00	2,87	0,41	4,31	0,51	1,92	1,00
RTS	0,75	0,39	0,06	0,80	7,79	0,65	0,72	0,40	1,33	0,25	7,16	0,71	0,13	0,72	0,86	0,35	7,90	0,64	0,95	0,81	2,29	0,81	7,24	0,70
SAX	2,86	0,09	2,71	0,10	8,39	0,59	0,23	0,63	0,68	0,41	8,86	0,55	0,07	0,79	0,53	0,47	9,08	0,53	4,66	0,20	9,23	0,10	7,90	0,64
SBI	0,00	0,95	0,65	0,42	1,87	1,00	0,04	0,85	0,15	0,70	1,87	1,00	0,04	0,84	0,53	0,47	1,87	1,00	0,11	0,99	1,22	0,94	1,89	1,00
WIG	0,11	0,74	0,53	0,47	76,81	0,00	0,00	0,98	0,35	0,55	76,11	0,00	0,02	0,90	1,65	0,20	75,89	0,00	0,18	0,98	1,80	0,88	76,50	0,00
CAC	0,05	0,82	1,32	0,25	6,10	0,81	0,43	0,51	0,93	0,34	5,58	0,85	0,48	0,49	0,16	0,69	6,22	0,80	1,76	0,62	6,32	0,28	5,69	0,84
DAX	0,14	0,71	0,50	0,48	10,97	0,36	0,10	0,75	0,75	0,38	10,53	0,40	0,92	0,34	0,38	0,53	10,90	0,37	1,52	0,68	3,33	0,65	10,90	0,37
FTSE	0,12	0,73	0,48	0,49	9,57	0,48	0,24	0,62	0,07	0,79	9,99	0,44	1,17	0,28	0,52	0,47	9,18	0,52	1,48	0,69	3,03	0,70	9,44	0,49
MIBTEL	0,37	0,54	0,53	0,47	7,20	0,71	0,03	0,87	0,36	0,55	6,81	0,74	0,92	0,34	0,58	0,45	6,85	0,74	1,40	0,71	5,33	0,38	6,64	0,76
NIKKEI	2,40	0,12	0,81	0,37	14,20	0,16	0,00	0,96	1,09	0,30	13,45	0,20	3,68	0,06	0,59	0,44	12,70	0,24	5,25	0,15	1,25	0,94	11,49	0,32
TSX	0,09	0,77	0,31	0,58	10,38	0,41	0,55	0,46	0,71	0,40	9,72	0,47	1,46	0,23	0,55	0,46	10,11	0,43	4,35	0,23	3,90	0,56	9,50	0,49

AR(1)

	SB	p-value	White	p-value	LB(10)	p-value	NSB	p-value	White	p-value	LB(10)	p-value	PSB	p-value	White	p-value	LB(10)	p-value	Joint	p-value	White	p-value	LB(10)	p-value
BUX	0,54	0,46	0,80	0,37	7,01	0,73	0,17	0,68	0,44	0,51	6,70	0,75	0,16	0,69	0,32	0,57	6,85	0,74	1,90	0,59	5,19	0,39	7,08	0,72
OMX	2,00	0,16	1,40	0,24	1,14	1,00	0,03	0,85	0,19	0,66	1,32	1,00	1,66	0,20	0,73	0,39	1,37	1,00	2,78	0,43	3,76	0,58	1,15	1,00
RTS	0,76	0,38	0,08	0,78	7,81	0,65	0,72	0,40	1,30	0,25	7,11	0,72	0,13	0,72	0,87	0,35	7,87	0,64	0,96	0,81	2,25	0,81	7,24	0,70
SAX	2,53	0,11	2,64	0,10	6,41	0,78	0,33	0,57	0,75	0,39	6,75	0,75	0,11	0,74	0,55	0,46	7,06	0,72	4,14	0,25	8,40	0,14	5,74	0,84
SBI	0,00	0,95	0,74	0,39	2,18	1,00	0,05	0,82	0,08	0,78	2,17	1,00	0,01	0,93	0,49	0,48	2,18	1,00	0,08	0,99	1,79	0,88	2,20	1,00
WIG	0,14	0,71	0,48	0,49	77,70	0,00	0,00	1,00	0,34	0,56	76,77	0,00	0,02	0,90	1,54	0,21	76,59	0,00	0,26	0,97	1,66	0,89	77,37	0,00
CAC	0,06	0,81	1,23	0,27	6,72	0,75	0,35	0,56	0,79	0,37	6,36	0,78	0,62	0,43	0,27	0,60	6,97	0,73	2,00	0,57	7,11	0,21	6,56	0,77
DAX	0,12	0,73	0,45	0,50	11,75	0,30	0,11	0,75	0,73	0,39	11,33	0,33	0,80	0,37	0,37	0,54	11,76	0,30	1,38	0,71	3,24	0,66	11,78	0,30
FTSE	1,15	0,28	0,01	0,94	10,59	0,39	0,39	0,53	0,21	0,65	11,24	0,34	1,58	0,21	0,73	0,39	10,33	0,41	1,71	0,64	1,18	0,95	10,29	0,42
MIBTEL	0,45	0,50	0,43	0,51	7,41	0,69	0,01	0,91	0,31	0,58	7,06	0,72	1,01	0,31	0,55	0,46	7,08	0,72	1,44	0,70	4,81	0,44	10,09	0,43
NIKKEI	2,25	0,13	0,78	0,38	14,13	0,17	0,01	0,94	1,08	0,30	13,44	0,20	3,65	0,06	0,62	0,43	12,77	0,24	5,14	0,16	1,25	0,94	11,47	0,32
TSX	0,18	0,67	0,10	0,76	24,96	0,01	0,30	0,58	0,58	0,45	25,57	0,00	0,38	0,54	0,32	0,57	25,52	0,00	1,91	0,59	2,60	0,76	27,85	0,00

SHARPE

	SB	p-value	White	p-value	LB(10)	p-value	NSB	p-value	White	p-value	LB(10)	p-value	PSB	p-value	White	p-value	LB(10)	p-value	Joint	p-value	White	p-value	LB(10)	p-value
BUX	0,54	0,46	0,80	0,37	7,01	0,73	0,17	0,68	0,44	0,51	6,70	0,75	0,16	0,69	0,32	0,57	6,85	0,74	1,90	0,59	5,19	0,39	7,08	0,72
OMX	0,02	0,89	0,54	0,46	1,70	1,00	0,32	0,57	0,33	0,57	1,80	1,00	1,86	0,17	0,59	0,44	2,25	0,99	2,57	0,46	3,21	0,67	2,32	0,99
RTS	0,01	0,91	0,93	0,33	9,44	0,49	0,15	0,70	0,47	0,49	9,41	0,49	0,03	0,87	1,29	0,26	9,19	0,51	0,26	0,97	2,08	0,84	9,10	0,52
SAX	3,13	0,08	2,86	0,09	6,83	0,74	0,31	0,58	0,74	0,39	7,17	0,71	0,08	0,78	0,53	0,47	7,48	0,68	5,04	0,17	9,38	0,09	6,23	0,80
SBI	0,01	0,92	0,65	0,42	1,83	1,00	0,00	0,99	0,16	0,69	1,84	1,00	0,02	0,88	0,51	0,48	1,85	1,00	0,08	0,99	1,12	0,95	1,86	1,00
WIG	0,12	0,73	0,48	0,49	47,03	0,00	0,66	0,42	0,46	0,50	44,24	0,00	0,03	0,86	0,04	0,85	48,30	0,00	0,72	0,87	0,53	0,99	43,87	0,00
CAC	0,20	0,65	1,51	0,22	6,17	0,80	0,85	0,36	1,13	0,29	5,24	0,88	0,03	0,85	0,45	0,50	6,25	0,79	1,31	0,73	3,65	0,60	5,13	0,88
DAX	0,00	0,99	1,82	0,18	7,63	0,67	0,42	0,52	1,18	0,28	6,88	0,74	0,30	0,58	0,96	0,33	7,27	0,70	1,23	0,75	3,55	0,62	6,49	0,77
FTSE	0,01	0,92	0,71	0,40	6,65	0,76	0,10	0,75	0,24	0,63	6,85	0,74	0,63	0,43	0,53	0,47	6,28	0,79	0,99	0,80	1,94	0,86	6,75	0,75
MIBTEL	0,42	0,52	0,53	0,47	5,74	0,84	0,22	0,64	0,76	0,38	5,15	0,88	0,39	0,53	0,32	0,57	5,41	0,86	1,65	0,65	4,28	0,51	5,24	0,87
NIKKEI	0,08	0,78	0,20	0,66	5,64	0,84	0,09	0,76	1,66	0,20	5,16	0,88	2,78	0,10	0,46	0,50	4,30	0,93	4,17	0,24	2,45	0,78	3,69	0,96
TSX	0,06	0,80	0,01	0,92	10,63	0,39	0,24	0,62	0,59	0,44	10,68	0,38	0,44	0,51	0,75	0,39	10,41	0,41	0,69	0,88	2,91	0,71	10,26	0,42

Tab. 7. Misspecification tests applied to EGARCH residuals

Conclusion

In the paper we employed a traditional GARCH model of Bollerslev (1986) and its asymmetric modification of Nelson (1991) to describe stock market returns in developed and Central European economies. Additionally we used an approach of Engle and Ng (1993) to test for asymmetric effects in analysed stock indices.

Both the tests and modelling framework gave a clear evidence of volatility clustering in the two groups of stock markets – GARCH approach seemed indispensable. The interpretation of that fact is that large deviations from the trajectory are followed by subsequent large deviations. On the other hand "quiet periods" happen when small deviations breed other small ones. However, in some cases, it was possible to find a specification of a conditional mean that was capable of describing ARCH effects.

From all analysed indices only the Polish one exhibited no typical asymmetric behavior. Thus a general statement seems justified that market reaction for negative news might be different than that for positive ones. Negative shocks tended to hit harder, i.e. they bred more uncertainty and stronger fluctuations to the market.

EGARCH specification performed well for developed markets, while describing asymmetric behavior in transition economies seems a more challenging task. The group of Central European economies is not internally homogenous and it requires a separate effort to model particular index returns. EGARCH parameters in CEE case were estimated with larger errors.

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Abstract

ARCH modelling framework of Engle (1982) and its GARCH generalization of Bollerslev (1986) gave a huge impetus to econometric model building in the field of financial time series with time-varying variance. The main idea of the models was to describe the most typical features of capital markets like volatility clustering, excess kurtosis and fat tails. As empirical evidence shows asymmetry is also a prominent feature of stock market returns volatility. The reaction of risk if stock returns go off the long run trajectory is different in case of positive and negative market news. Thus it is indispensable to employ asymmetric models being a modification of a traditional GARCH. In the paper we used an approach of Engle and Ng (1993) to test for asymmetric effects in stock indices of developed and Central European stock markets.

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