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A COMPARISON OF THE IPO METHODS FOR SPORT STOCKS: EVIDENCE FROM ISTANBUL STOCK EXCHANGE MARKET

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Abstract

The significance of the sports economy has been increasing nowadays in the world. Following this trend, it has improved in Turkey as well. Sports clubs must have enough resources to keep up with this improvement. Hence, sports finance has become vital for sports clubs. Despite the increase in their earnings, they have been resorting to public offerings (IPOs) as an alternative source of funding. The IPOs method may be vital for increasing their market value. Within this context, the purpose of the study is to investigate the risk structure of sports stocks trading in Istanbul Stock Exchange Market to understand which IPOs method is effective for Turkish sport sector. The findings of this study imply that *capital increase method* is more effective than *sale of share holder(s)* method for sport sector. Additionally, those stocks seem to be still volatile for investors, and the sports industry appears to have a high level of risk for new public offerings in the future for Turkey.

Key words: Sport stocks, volatility, ARMA, GARCH, ISE.
Jel Classification: G11, G10, C22

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[1]

INTRODUCTION

Sport clubs are big organizations. They spend great funds for player transfers, investments, and organizational activities. So they search for new source alternatives such as public offering. In the world there are so many successful examples which go public offering and enhance their market value as Manchester United, Arsenel, Chelse. But going public offers always not enhance sport clubs market value. For example; Juventus reached 167 million dollar revenue after public offerings, but the market value of Juventus decreasing from 442 million dollar to 369 million dollar. So the time of public offering and the IPOs method are vital for successfulness. At this view point, the public offering of sport club is increasing last six years in Istanbul Stock Exchange Market. The primer sport clubs announced for public offering are Besiktas and Galatasay. Fenerbahce and Trabzonspor followed them. The detailed of public offering characteristics are presented at Table 1.

Capital increases or sale of shareholders is different IPOs method for dimension of reporting financial statement and dividend distribution process. To understand which method is effective for turkey we investigate the risk structure of sports clubs, which have gone public before. It is important for new public offerings in the future.

In the literature, in our knowledge, this study is fist study performing a univariate analysis of the time series properties of the returns on four stocks that happen to be sports related. We have a univariate analysis, while the papers in this area use variation in on-field outcomes to explain observed variation in returns. This is quite different from the analysis in our paper. Because, in the literature, the risk structure of stocks are measured volatility as standard deviation of return series. But after ARCH class model take place in the literature, most studies used ARCH class models which measured volatility more effective than just a standard deviation of return series (Baillie, DeGennaro, 1990)

In the literature, Academics, practitioners, investors and regulators are interested in stock market volatility. Thus, the literature has been growing in the stock market of individual countries (Balaban, Bayar and Kan, 1999; Tse, 1995; Tse and Tung 1992, Dimson and Marsh, 1990) and foreign exchange markets (Taylor, 1987; Lee, 1991; Andersen and Bollerslev, 1998). For Turkey, the studies are fundamentally based on modeling stock market volatility (Muradoğlu, Berument and Metin, 1999, Yalçın 2006; Telatar and Binay, 2002; Akgül and Sayan, 2005; Mazıbaş, 2005). When we review the literature related to economics of sports, we can see a great number of studies examining the relationship between success in sports and economic performance (Pollard, 2002; Coates and Humphreys, 2002, Azarmi, 2002, Berument and Yucel, 2005). For example, Arshton and et all (2003) stated a strong relationship between the performance of the England football team and FTSE 100 index. In Turkish literature, few studies investigate sport stocks. Berument, Ceylan and Gozpinar (2006) investigate the effect of soccer success on stock market returns and concluded that the success of Besiktas has considerable effects on ISE-100. Tufan (2004) examines the effects of world cup football matches on the ISE-100 index return and stated that World Cup matches 2002 could not have any effects on ISE-100. This study differentiates from previous research because of investigating the risk structure of sport stocks using a univariate analysis to understand which IPOs method is effective for Turkey. For this purpose, this paper is organized as follows: Section II, describes the research method employed. Section III describes data, Section IV stresses research restrictions. Section V shows the empirical evidence. Section VI provides the summary and conclusion.

Turkish football industry and Turkish Stock Exchange market:

The Turkish National Football League was established in 1959. The number of teams was fixed at 18 after the 1995 season. At present, all the football teams play each other during the season. The winning team receives 3 points, while the losing team gets no points, additionally ties get 1 point. At the end of the season, the team having the highest score wins the championship. The teams to playing the Turkish Cup are determined by the Turkish Football Federation on the basis of their previous performance in the Turkish Cup and in the Turkish National Football League (Brument and Yucel, 2005).

Besiktas spor club
The district also gives its name to Turkey's oldest sports club, Beşiktaş Jimnastik Kulübü (Beşiktaş Gymnastics Club), founded in 1903. The club's football team is one of the top three in Turkey. The club's 32,000-seater BJK İnönü Stadium is on the Bosphorus sea-front just before the centre of Beşiktaş. The football team wears black-and-white shirts and are nicknamed the "Black Eagles". The club competes in numerous branches including football, basketball, volleyball, handball, athletics, boxing, wrestling, chess, cards bridge, gymnastics, rowing, table tennis, and paralympic sports (http://en.wikipedia.org/wiki/Besiktas).

Galatasaray spor club
Galatasaray Sports Club is founded in 1905. Ali Sami Yen stadium is the home of the football club Galatasaray in Istanbul, Turkey. The stadium has a capacity of 23,785. Galatasaray is the most successful club in the history of Turkish football, having won more trophies than any other Turkish club. They became the first Turkish club to capture a major European title, winning the UEFA Cup final during the 1999–2000 season. They lifted another prestigious trophy when they won the Super Cup same year. The football team wears yellow-and-red shirts and are nicknamed the Cimbom or Yellow Reds. The club also operates amateur sport teams that compete at Athletics, Basketball, Wheelchair basketball, Volleyball, Water polo, Swimming, Rowing, Sailing, Judo, Bridge and Motorsports
(http://en.wikipedia.org/wiki/Galatasaray).

Fenerbahce spor club
Fenerbahçe Sports Club is founded in 1907. Fenerbahçe is one of the most popular sports clubs in Turkey. The most famous branch of the club is football. The football team wears yellow-and- dark blue shirts and are nicknamed The Yellow Canaries. Fenerbahce football team play their home games at Şükrü Saracoğlu Stadyumu in Kadıköy. The total capacity of the stadium is 52.056. The club also competes in basketball, volleyball, rowing, boxing, sailing, athletics, swimming, and table tennis. Fenerbahçe celebrated its centennial year in 2007. (http://en.wikipedia.org/wiki/Fenerbahce).

Trabzonspor spor club
Trabzonspor was formed in 1967 in a merger of two local clubs. Trabzonspor is the only club outside Istanbul to have won the Turkish title, earning a name as one of the "Big Four" alongside Fenerbahçe, Galatasaray, Beşiktaş. Trabzonspor's nicknames are the "Burgundy Blues" and the "Black Sea storm". Hüseyin Avni Aker Stadium is the home ground of the Trabzonspor. It was built in 1951 with a capacity of 2,500 only
(http://en.wikipedia.org/wiki/Trabzonspor).

Turkish stock exchange market:

The Istanbul Stock Exchange (ISE) was established in early 1986. The ISE is the only securities exchange in Turkey established to provide trading in equities, bonds and bills, revenue-sharing certificates, private sector bonds, foreign securities and real estate certificates as well as international securities. As an autonomous, professional organization, the ISE enjoys a high degree of self-regulation. Its revenues are generated from fees charged on transactions, listing procedures and miscellaneous services. The profits of the ISE are retained to meet expenses and to undertake investments and are not distributed to any third parties. The ISE has its own budget. Decree-Law No:91 concerning securities exchanges is published in the Official Gazette No:18183 dated October 6, 1983. The Decree foresees the establishment of a stock exchange in Turkey for the purpose of creating a medium for securities operations with the objective of making Turkey's capital markets more efficient. The regulations outlining the functions and operations of a stock exchange in Turkey were published in the Official Gazette No:18537 dated October 6, 1984. The Regulations outline the nature and functions of members and their responsibilities as well as other aspects of trading on the ISE (http://www.ise.org/aboutise.htm).

DATA AND RESEARCH METHOD

This study covers 4 quoted sports stocks in ISE and ISE-100 index as stated Table 1. The data required for analyzing were obtained from Istanbul Stock Exchange Market, for the period 15.04.2005-14.09.2007 when all four stocks were trading on the stock exchange market. Eviews 5.1 software package was used for the analysis.

[Table 1]

To investigate the risk structure of sports stocks trading in Istanbul Stock Exchange, we used univariate analysis as GARCH models. For applying this method, the return series don't have unit root. Firstly, Augmented Dickey-Fuller unit root test (ADF) is applied for checking the unit root process of this series (Dickey and Fuller, 1981)[i]. Results of Augmented Dickey-Fuller (ADF) unit root tests, reported in Table-3.

[Table 3]

The results of the unit root test show that all sports stocks and ISE-100 index returns are stationary. As a result of Table 3, for all the series, the null hypotheses of unit root were rejected (calculated t-test values for all variables, which are higher than t-test table values).

Secondly, for modeling conditional mean, we must primarily detected the fitted AR, MA and ARIMA models using autocorrelation and partial autocorrelation function[ii]

Thirdly, after determining the conditional mean, we test for autoregressive conditional heteroscedasticity (ARCH) in the residuals using Lagrange multiplier (LM) (Engle 1982)[iii]. Lastly, having confirmed the persistence of conditional heteroscedasticity, we now focus on the volatility modeling using ARCH models (Tsay, 2005)[iv].

Research Restrictions

This study was applied only to Turkish sport stocks which were quoted on ISE for the period 15 th of April 2005 to the 14 th of September 2007. Therefore, the results may not be generalized to all sports stocks in the world.

Empirical Findings

For modeling the conditional mean, we decided to analyze which of the AR, MA and ARIMA models best describe the conditional mean. The parameters estimated are presented in Table-4.

[Table 4]

To test for the persistence of conditional heteroscedasticity, we calculated the Lagrange Multiplier test for ARCH effects. These results reported in Table-5.

[Table 5]

The LM test results validate the rejection of the homoskedasticity assumption.
In this respect, the GARCH (1,1) model seems to be the fitted model, as it incorporates the ARCH processes verified by the ARCH LM test. The estimated parameters of the fitted model are displayed in Table 6.

[Table 6]

CONCLUSION

The present paper employs GARCH models for BJK, TS, GS, FB, ISE-100 to determine the risk structure of sports stocks in Istanbul Stock Exchange Market for the period 15 th of April 2005 and14 th of September 2007 to understand the risk structure of sports clubs, which have gone public before, is important for new public offerings in the future.
For this purpose, firstly the stationarity of the series is tested by ADF unit root test, the residual terms seem to be normally distributed according to ADF. Secondly, for modeling the conditional mean, we detected to fitted AR(1), MA(1) for both BJK and TS; AR(2), MA(2) for GS; AR(1) for FB; AR(4), MA(4) for ISE-100. Thirdly, the GARCH (1,1) model was estimated to model the conditional volatility of all sport stocks and ISE-100 index, since the LM test results validate the rejection of the homoskedasticity assumption. Furthermore, the volatility level of BJK, TS, GS, FB, ISE-100 time series are presented in Attachment-1 respectively.
We can observe that the estimated volatility figures of the sport stocks range from 0,0943% to 6,3808% ,
[BJK(0,0943%)<ISE-100(0,5443%)<GS(2,2235%)<FB(2,4459%)<TS(6,3808%)] ,
as demonstrated in Table-7.

[Table 7]

As a result; the least volatile stock is BJK used capital increase method, whereas the most volatile is TS which used sale of shareholders' method. In addition, TS, FB and GS are more volatile than the stock market which all of three stocks are used the mothod of sale of shareholder, while BJK is less volatile than the market. The findings of this study imply that those stocks used sale of shareholders method seem to be still volatile for investors[2].

[2] We investigate whether the expected return on an asset is related to the expected asset risk or not by applying GARCH-M(1,1) model, where the conditional variance or standard deviation take place in the mean equation. (Engle, Lilien and Robins, 1987). The estimated coefficient on the expected risk , which measures the risk-return tradeoff, is not statistically significant for all the models. Thus, it may not be appropriate to conclude that high risk brings high expected returns for these sports stocks.

Moreover, the sports industry appears to have a high level of risk for new public offerings in the future. We may suggest that sports clubs which plan to go public should consider the use of capital increase method, additionally, since the vast majority of the investors may not be willing to undertake the high level of risk inherent in the primary markets of the sports stocks, which may limit the amount of funds received from the IPOs.

This result just emphasizes the risk structure of sports stocks in Istanbul Stock Exchange Market for the period 2005-2007 in Turkey. So for further studies, it is investigated for developed countries and other emerging countries risk structure of sports stocks. Additionally, the relationship between the results of the sport matches and the economic performance of those corresponding stocks can be investigated too.

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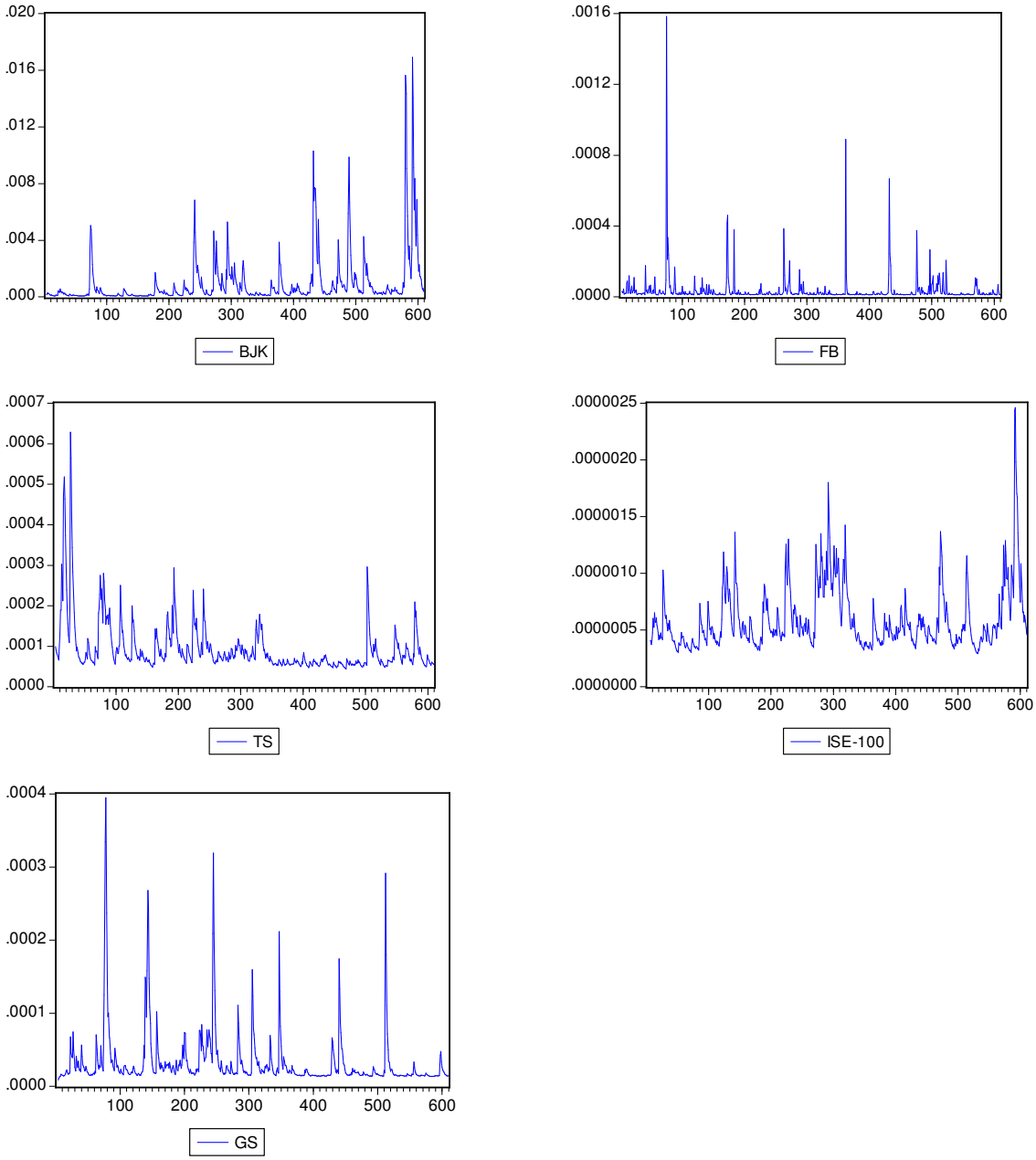
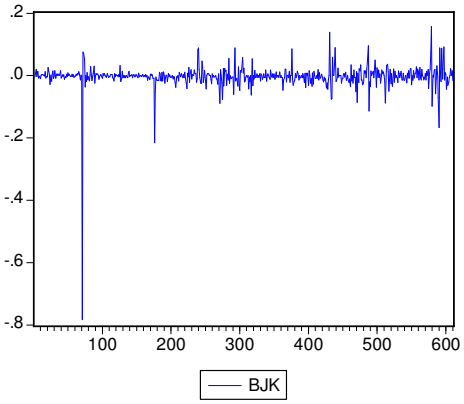
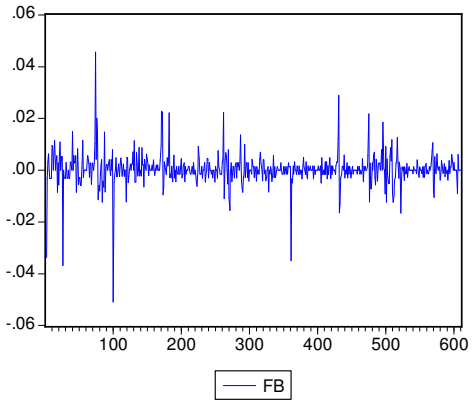
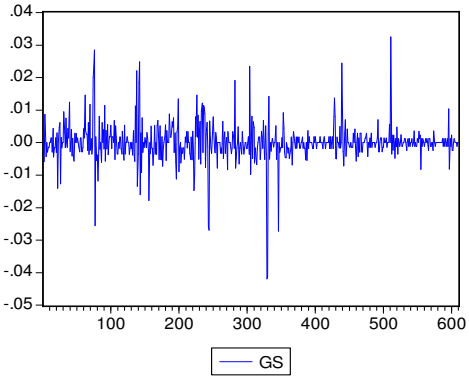
Attachment 1: Estimated volatility's time series



Graph 1: Sport stocks returns time series


.2
.0
-.2
-.4
-.6
-.8
100
200
300
400
500
600
BJK


.06
.04
.02
.00
-.02
-.04
-.06
100
200
300
400
500
600
FB


.04
.03
.02
.01
.00
-.01
-.02
-.03
-.04
-.05
100
200
300
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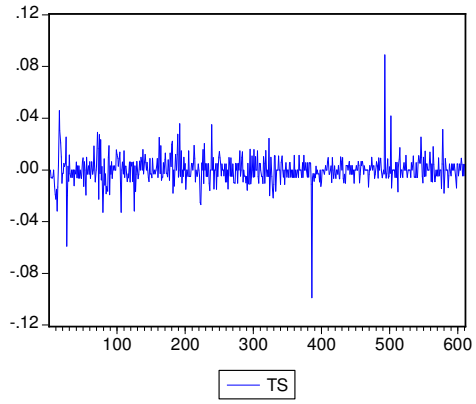
GS


.12
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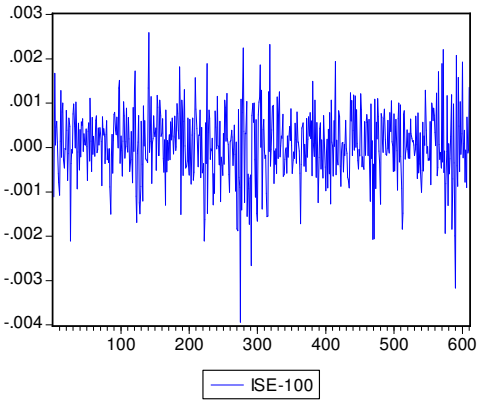
TS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100
200
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600
ISE-100

Table 1: The IPO characteristic of sport club in Turkey

Name of Company	Total revenie (USD)	Rate (%)	IPO Price (TL)	IPO Method	Underwring method	Sales Method	IPO Date	First Trading Date
BJK	14.018.515	15	57.500	Capital Increase	Residual Underwriting	Fixed price offer	14-15.02.2002	20.02.2002
GS	21.152.156	16	87.000	Sale of shareholder(s)	Residual Underwriting	Fixed price offer	14-15.02.2002	20.02.2002
FB	30.030.087	15	10.500	Sale of shareholder(s)	Residual Underwriting	Fixed price offer	12-13-16.02.2004	20.02.2004
TS	24.567.610	25	5,25	Sale of shareholder(s)	Residual Underwriting	Fixed price offer	06-07-08.04.2005	15.04.2005

*ISE stock market: (http://www.ise.org/data.htm#ipo)

Table 2: The Sport stocks Listed on ISE

Code	Name
BJK	Besiktas Futbol Yatırımları Sanayi ve Ticaret A.S.
TS	Trabzonspor Sportif Yatirim ve Ticaret A.S.
GS	Galatasaray Sportif Sınai ve Ticari Yatırımlar A.S.
FB	Fenerbahçe Sportif Hizmetler Sanayi ve Ticaret A.S
ISE–100	Istanbul Stock Exchange Market Index-100

Table 3: Sport stocks returns summary statistic

	Mean	**Median**	**Maximum**	**Minimum**	**Std. Dev.**	**Skewness**	**Kurtosis**
BJK	-0.003158	.000000	0.156811	-0.782334	0.041315	-1.113.090	2.113.778
TS	0.000115	.000000	0.089010	-0.098836	0.011061	-0.266711	2.184.905
GS	0,027153	.000000	0.032537	-0.041864	0.005995	-0.534031	1.611.834
FB	0.000345	.000000	0.045697	-0.050907	0.006123	-0.688489	2.230.056
ISE–100	0.0376651	5.37E-05	0.002586	-0.003939	0.000787	-0.436565	4.731.962

Table 4: Unit root tests result

Variable	ADF- t statistic- for the model without trend	ADF- t statistic - For the model with trend
BJK	-25.91075*	-25.93062**
TS	-24.04731*	-24.06188**
GS	-23.20390*	-23.19921**
FB	-23.92914*	-23.94751**
ISE–100	-23.81723*	-23.82595**

* MacKinnon critical values for the significance level of 1 %, 5 % and 10 % respectively are as follows: - for the model without trend -3,43, -2,86 and -2,56, for the model with trend ; -3,96, -3,41 and -3,12.

Table 5: ARMA models parametric estimates

	Variable	Coefficient	Std. Error	t-Statistic	Prob.
BJK	C	-0.001606	0.000772	-2.080991	0.0379
	D[3]BJK1	-0.769201	0.025027	-30.73486	0.0000
	DBJK2	-0.220480	0.025013	-8.814504	0.0000
	AR(1)	0.741342	0.163683	4.529142	0.0000
	MA(1)	-0.806102	0.144419	-5.581693	0.0000
TS	*C*	0.000292	0.000286	1.018518	0.3088
	DTS1	-0.100622	0.009620	-10.45958	0.0000
	DTS2	0.088992	0.009618	9.252389	0.0000
	AR(1)	0.897287	0.061720	14.53804	0.0000
	MA(1)	-0.927172	0.053734	-17.25484	0.0000
GS	*C*	0.000173	0.000219	0.789305	0.4302
	DGS1	-0.042050	0.005482	-7.670663	0.0000
	DGS2	-0.040800	0.005482	-7.442302	0.0000
	AR(2)	-0.913959	0.076511	-11.94539	0.0000
	MA(2)	0.882819	0.088942	9.925831	0.0000
FB	*C*	0.000574	0.000237	2.422358	0.0157
	DFB1	-0.012804	0.005347	-2.394684	0.0169
	DFB2	-0.051642	0.005353	-9.647358	0.0000
	DFB3	-0.037682	0.005348	-7.045721	0.0000
	AR(1)	0.081049	0.039372	2.058559	0.0400
ISE–100	*C*	6.16E-05	3.12E-05	1.970249	0.0493
	DISE100	-0.004004	0.000769	-5.209411	0.0000
	AR(4)	-0.760196	0.158613	-4.792773	0.0000
	MA(4)	0.761410	0.158751	4.796250	0.0000

[3] In Table-4, D expresses the dummy variables which are created to eliminate the outliers' effect. In this context, DBJK1, DBJK2; DTS1, DTS2; DGS1, DGS2; DFB1, DFB2, DFB3; DISE100 are created for the following observation days (610 observations exist for the period from the 15th of April 2005 to the 14th of September 2007) respectively: 71,176; 386, 493; 329, 330; 26, 74, 100; 275.

Table 6: Lagrange-multiplier test results

BJK	F-statistic	13.20933	Prob. F(4,599)	0.000000
	Obs*R-squared	48.95967	Prob. Chi-Square(4)	0.000000
TS	F-statistic	7.793211	Prob. F(4,599)	0.000004
	Obs*R-squared	29.87815	Prob. Chi-Square(4)	0.000005
GS	F-statistic	17.89121	Prob. F(4,598)	0.000000
	Obs*R-squared	64.45020	Prob. Chi-Square(4)	0.000000
FB	F-statistic	4.024125	Prob. F(4,599)	0.003142
	Obs*R-squared	15.80612	Prob. Chi-Square(4)	0.003291
ISE–100	F-statistic	7.688342	Prob. F(4,596)	0.000005
	Obs*R-squared	29.48971	Prob. Chi-Square(4)	0.000006

Table 7: Volatility models parametric estimates

Fitted Garch Models						
	Model		**Coefficient**	**Std. Error**	**z-Statistic**	**Prob.**
BJK	*GARCH (1,1)*	C	2.13E-05	3.44E-06	6.176401	0.0000
		RESID(-1)^2	0.517801	0.046827	11.05776	0.0000
		GARCH(-1)	0.627286	0.023425	26.77901	0.0000
TS	*GARCH (1,1)*	*C*	1.07E-05	2.73E-06	3.901849	0.0001
		RESID(-1)^2	0.143042	0.033694	4.245330	0.0000
		GARCH(-1)	0.745418	0.053644	13.89567	0.0000
GS	*GARCH (1,1)*	*C*	5.67E-06	6.69E-07	8.472457	0.0000
		RESID(-1)^2	0.265281	0.054691	4.850508	0.0000
		GARCH(-1)	0.585122	0.043865	13.33901	0.0000
FB	*GARCH (1,1)*	*C*	1.09E-05	9.07E-07	12.06312	0.0000
		RESID(-1)^2	0.726664	0.059140	12.28725	0.0000
		GARCH(-1)	0.106946	0.037243	2.871569	0.0041
ISE–100	*GARCH (1,1)*	C	6.04E-08	2.44E-08	2.480242	0.0131
		RESID(-1)^2	0.134013	0.039099	3.427492	0.0006
		GARCH(-1)	0.767053	0.067450	11.37224	0.0000

Table 8: Summary statistic for estimated volatility

	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis
BJK	0,000943	0,000321	0.016927	6.45E-05	0.001845	4.656.90	3.058.82
TS	0,063808	0,048985	0.000628	4.43E-05	6.51E-05	3.717.95	2.233.53
GS	0,022235	0,013476	0.000395	8.46E-06	4.09E-05	4.673.54	2.979.77
FB	0,024459	0,011455	0.001583	1.23E-05	9.03E-05	11.02570	162.3377
ISE–100	0,005443	0,004614	2.46E-06	2.92E-07	2.79E-07	2.242.18	1.085.62

[i] Firstly, we tested the stationarity of time series using "Augmented Dickey-Fuller (ADF)" method (Dickey and Fuller, 1981). The models suggested for this test are as follows:

Model without a constant term : $\Delta Y_t = \delta Y_{t-1} + \sum_{i=2}^{m} \beta_i \Delta Y_{t-i+1} + \varepsilon_t$ (1)

Model with a constant term : $\Delta Y_t = \alpha_0 + \delta Y_{t-1} + \sum_{i=2}^{m} \beta_i \Delta Y_{t-i+1} + \varepsilon_t$ (2)

Model with a constant term

and trend factor : $\Delta Y_t = \alpha_0 + \delta Y_{t-1} + \beta_t + \sum_{i=2}^{m} \beta_i \Delta Y_{t-i+1} + \varepsilon_t$ (3)

Here, ΔY_t denotes the first difference of the variable tested for stationarity, t denotes the general trend variable and t ΔY_{t-1} denotes the lagged difference terms.

This test is done by comparing the calculated ADF-t statistic with the MacKinnon critical values. If the absolute value of the ADF-t statistic is greater than the MacKinnon critical value, then the time series analyzed can be considered as stationary. Otherwise, the series cannot be considered as stationary. In order to determine the order of lag, Akakike and Schwarz criteria are exercised.

[ii] . In this context, if a time series can be expressed as a function of its lagged values, it can be defined as an autoregressive process and can be formulated as in Formula 4:

$Y_t = \delta + \alpha_1 Y_{t-1} + \alpha_2 Y_{t-2} + \ldots\ldots\ldots + \alpha_p Y_{p-1} + \varepsilon_t$ (4)

If the value of a variable at time t is determined by the lagged value of the residual in the same period and the previous, this process is defined as a MA process and can be stated as in Formula 5:

$Y_t = \mu + \varepsilon_t + \beta_t \varepsilon_{t-1} + \ldots\ldots\ldots\ldots + \beta_q \varepsilon_{t-q}$ (5)

From time to time, it is more appropriate to model time series as a combination of autoregressive and moving average components. These processes are called ARMA processes and can be stated as in Formula 6 (Enders, 2004):

$Y_t = \delta + \alpha_1 Y_{t-1} + \alpha_2 Y_{t-2} + \ldots\ldots + \alpha_p Y_{p-1} + \varepsilon_t + \beta_t \varepsilon_{t-1} + \ldots\ldots\ldots\ldots + \beta_q \varepsilon_{t-q}$ (6)

[iii] The ARCH LM test statistic is computed from an auxiliary test regression. To test the null hypothesis that there is no ARCH up to order in the residuals, we run the regression:

$$\varepsilon_t^{\,2} = \beta_o + \left(\sum_{s=1}^{q} \beta_s \varepsilon_{t-s}^{\,2} \right) + v_t \quad (7)$$

where ε_t is AR-MA residuals.

[iv] The most popular class of models for conditional volatility is the AutoRegressive Conditional Heterocedasticity (ARCH) class of models introduced by Engle (1982) stated as follows:

$$r_t = E\left[r_t \middle| \Omega_{t-1} + \varepsilon_t\right] \quad (8)$$

$$\varepsilon_t = z_t \sqrt{h_t} \qquad z_t \sim IIDN(0,1) \quad (9)$$

$$E\left[\varepsilon_t \middle| \Omega_{t-1}\right] = 0 \text{ and conditional variance of } \varepsilon_t \quad (10)$$

$$E\left[\varepsilon^2{}_t \middle| \Omega_{t-1}\right] = E\left[h_t\right] \quad (11)$$

For this perspective, ARCH(1) models stated as follows:

$$h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}{}^2 + \text{vt} \quad (12)$$

$$\alpha_0 > 0,\ 0 < \alpha_1 < 1 \text{ dir.} \quad (13)$$

For ARCH(q) models:

$$h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}{}^2 + \alpha_2 \varepsilon_{t-2}{}^2 + ... + \alpha_q \varepsilon_{t-q}{}^2 + \text{vt} \quad (14)$$

$$\alpha_0 > 0,\ \alpha_i \geq 0 \text{ dir.} \quad (15)$$

The GARCH models, which are generalized ARCH models, allow for both autoregressive and moving average components in the Heteroscedastic variance developed by Bollerslev (1986) and stated as follows:

$$r_t = \sqrt{h_t}\,\varepsilon_t \quad (16)$$

$$h_t = \alpha_0 + \sum_{i=1}^{q} \alpha_i r^2{}_{t-i} + \sum_{j=1}^{p} \beta_j h_{t-j} \quad (17)$$

$$\alpha_0 > 0 \quad (18)$$

$$\alpha_i \geq 0 \ \forall\ i \geq 1 \quad (19)$$

$$\beta_j \geq 0 \ \forall\ j \geq 1 \quad (20)$$