REMARKS ON ROMANIAN CAPITAL MARKET VOLATILITY IN THE FRAMEWORK OF AN Power ARCH (PARCH) Model

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The recent evolution of the Romanian capital market is characterized by an increase in the market volatility as an expression of investors' uncertainty about the global financial instability. Thus, the objective of this study is to provide an analytical framework for the analysis of the market volatility and to derive some empirical evidences based on such framework. The methodological framework is based on ***a Power Arch Model****. For this type of model, the main advantage consists in the fact that the power parameter of the standard deviation can be estimated rather than imposed, and some optional parameters are added to capture asymmetry in the volatility' dynamic which confers a higher flexibility of the volatility description. The main results support the thesis that there could be evidenced some recent structural changes in the market' volatility pattern, changes which had occurred as a direct effect of the financial and real crisis and also as a specific response of the Romanian capital market.*

Key words: capital market, volatility, Power Arch Model, Bucharest Stock Exchange.

JEL Classification: G01, G10, G15.

1. Introduction

The recent global instability was spread both among mature as well as emergent capital markets. With the sharp slowdown in the financial and real international flows, credit deterioration and capital flight from illiquid and risky markets, the emergent markets were lost significantly from their previous attractiveness and start the display several characteristics of functional instability.

In the context of the international financial structural adjustments, the Bucharest Stock Exchange (BSE) suffered and the adjustment process was mainly under the impact of the foreign capital outflows. More exactly, studying the recent BSE's evolutions, one could reveal the existence of certain development stages: the initial stage, (1995-1996) that led to the high growth in the first part of 1997; the second one, starting from the second part of 1997 to 1999, when the BSE regressed; the third stage, starting from 2000, when the BSE started to develop a long term solid foundation. After 2000 the evolution of the BSE was relatively favorable with high peaks for 2004 – 2005. But at the end of 2005, a structural change in the market upward trend occurred and a downward trend for the market prices took place. As a consequence, the pattern of the global market volatility changed and multiple "volatility peaks" appeared. Thus, the objective of this study is to provide in Section 2 an analytical framework for the study of the market volatility, to apply in Section 3 this framework to the empirical data and to finally formulate some partial conclusion about a further more analytical research required by the study of this topic.

2. Analytical Framework

One of the best designed frameworks for the volatility' study is represented by the so-called ARCH / GARCH models. More exactly, Autoregressive Conditional Heteroskedasticity (ARCH) models are specifically designed to model and forecast conditional variances. The variance of the dependent variable is modelled as a function of past values of the dependent variable and independent or exogenous variables.

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ARCH models were introduced by Engle (1982) and generalized as GARCH (Generalized ARCH) by Bollerslev (1986) and Taylor (1986).

In order to describe the BET index volatility we are employing a special class of ARCH models - the so - called *Power ARCH (PARCH) Model*. The choice is motivated by the fact that power parameter δ of the standard deviation can be estimated rather than imposed, and the optional γ parameters are added to capture asymmetry of up to order τ which confers a higher flexibility of the volatility description:

$$\sigma_t^{\delta} = \omega + \sum_{j=1}^{q} \beta_j \sigma_{t-j}^{\delta} + \sum_{i=1}^{p} \alpha_i \left(\left| \varepsilon_{t-i} \right| - \gamma_i \varepsilon_{t-i} \right)^{\delta} \quad (1)$$

Here

$\delta > 0, |\gamma_i| \leq 1,$

for $i = 1,2,\ldots\tau, \gamma_i = 0$.

for all $i > \tau$ and $\tau \leq p$

Also, for an adequate evaluation of the estimation' quality it is useful to compare the estimated *PARCH* volatility with a proper baseline estimator. In this study, we are appealing the *historical volatility*, $\sigma_t^{2\ hist}$ computed as a convex combination of volatilities over a m length moving window:

$$\sigma_t^{2\ hist} = \sum_{i=t-m}^{t} w_i \sigma_i^2 \quad \text{with} \quad w_i = \frac{i}{\sum_{i=1}^{m} i} \quad (2)$$

The basic idea is that, at least "on long run", the estimated *PARCH* volatility could not systematically deviate from the baseline if the calibration of the model displays an adequate quality.

3. Data and Empirical Results

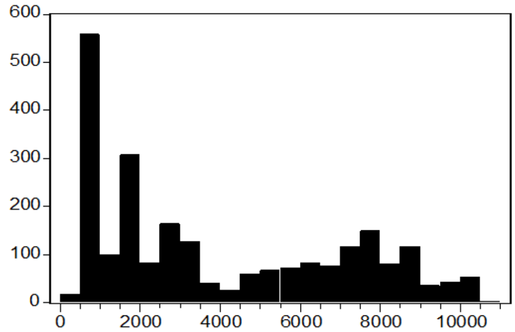
In order to reflect the market evolutions and subsequently the structural and functional factors which leaded to changes in its volatility pattern, we shall use the BET index. This index was the first one to be created by the Bucharest Stock Exchange as a market reference. BET is a free float weighted capitalization index of the 10 most liquid companies listed on the BVB regulated market. Data consists in daily close values of the index for a period between 1/5/2000-6/5/2009 (see also http://www.bvb.ro/IndicesAndIndicators/indices.aspx). The choice of the data frequency was motivated by the purpose of capturing the "short-run" changes in the index volatility.

Table 1 reports the distribution characteristics of the index. According to this, this distribution is a non - "normal" one with significant "fat tails" effects. Even more, the tabulation suggests that there are some important changes in the distributional parameters (*Skewness* and *Kurtosis*) at higher values of the indexes. However, for more than 62% of the data, the distribution is dominated by a long right tail and a flat (*platykurtic*) relative to the normal display.

Also it could be noticed that the overall volatility, measured by the variance coefficient- the ratio between the standard deviation and the mean- coefficient which is close to 0.78,

Table 1

The distribution of the BET index



Series: BET	
Observations 2371	
Mean	3963.144
Median	2931.090
Maximum	10813.59
Minimum	0.000000
Std. Dev.	3089.528
Skewness	0.486077
Kurtosis	1.785285
Jarque-Bera	239.1368
Probability	0.000000

Descriptive Statistics for BET
Categorized by values of BET
Included observations: 2371

BET	Mean	Median	Max	Min.	Quant.*	Sum.	Std. Dev.	Skew.	Kurt.	Obs.
[0, 5000)	1780.700	1660.110	4998.150	0.000000	1660.110	2635435.	1204.970	0.803613	2.783188	1480
[5000, 10000)	7412.793	7508.210	9990.220	5016.630	7508.210	6189682.	1250.905	-0.064620	2.184526	835
[10000, 15000)	10205.29	10167.68	10813.59	10002.34	10167.68	571496.0	177.0852	1.569533	5.678365	56
All	3963.144	2931.090	10813.59	0.000000	2931.090	9396614.	3089.528	0.485975	1.784532	2371

*Quantiles computed for p=0.5, using the Cleveland definition.

seems to be important for the entire analysis period.

In order to further clarify the issue of normal / non-normal nature of the data distribution, several normal distribution tests are employed (*Table 2*). For all these tests, the empirical values reject the null of a normal distribution.

The index could be described as an *I (1)* process. More exactly, the appliance of the *Augmented Dickey-Fuller* unit root test with constant and linear trend as exogenous variable (*Table 3*) on index level and first order differences indicates that the index is stationary at order 1.

Since the deviation from the normal distribution could be seen as a sign of market' informational dysfunctions, a "weak efficiency form" random walk test for the log returns of index is applied (*Table 4*). From this table, it appears that

Table 2

Empirical Distribution Test for BET

Hypothesis: Normal
Included observations: 2371

Method	Value	Adj. Value	Probability	
Lilliefors (D)	0.152786	NA	0.0000	
Cramer-von Mises (W2)	16.80378	16.80732	0.0000	
Watson (U2)	15.93267	15.93603	0.0000	
Anderson-Darling (A2)	99.73687	99.76846	0.0000	
Method: Maximum Likelihood - d.f. corrected (Exact Solution)				
Parameter	Value	Std. Error	z-Statistic	Prob.
MU	3963.144	63.44922	62.46166	0.0000
SIGMA	3089.528	44.87484	68.84766	0.0000
Log likelihood	-22416.62	**Mean dependent var.**		3963.144
No. of Coefficients	2	**S.D. dependent var.**		3089.528

Table 3

The unit root ADF test for BET index

Null Hypothesis: BET (level) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 5 (Automatic based on Modified HQ, MAXLAG=26)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		**-0.113855**	**0.9947**
Test critical values:	**1% level**	-3.961925	
	5% level	-3.411708	
	10% level	-3.127734	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(BET) (first order differences) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic based on Modified HQ, MAXLAG=26)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		**-77.16590**	**0.0001**
Test critical values:	**1% level**	-3.961919	
	5% level	-3.411705	
	10% level	-3.127732	

*MacKinnon (1996) one-sided p-values.

Table 4

The random walk test for the log returns of BET index

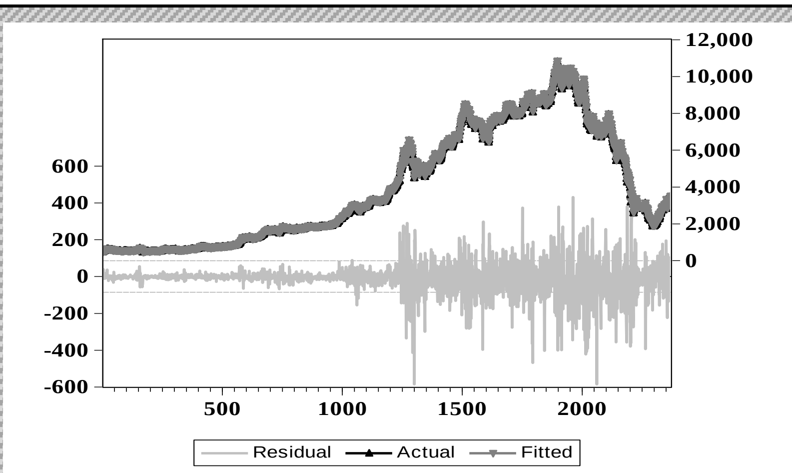
	Coefficient	Std. Error	z-Statistic	Prob.
C(2)	-8.013843	0.014432	-555.2933	0.0000
C(3)	0.000861	0.000380	2.268674	0.0233
	Final State	**Root MSE**	**z-Statistic**	**Prob.**
SV1	*8.174025*	*0.018189*	*449.3862*	*0.0000*
Log likelihood	6122.780	**Akaike info criterion**		-5.165215
Parameters	2	**Schwarz criterion**		-5.160346
Diffuse priors	1	**Hannan-Quinn criterion**		-5.163443

Table 5

Empirical Distribution Test for BET

Dependent Variable: BET
Method: ML - ARCH (Marquardt) - Generalized error distribution (GED)
Included observations: 2370 after adjustments

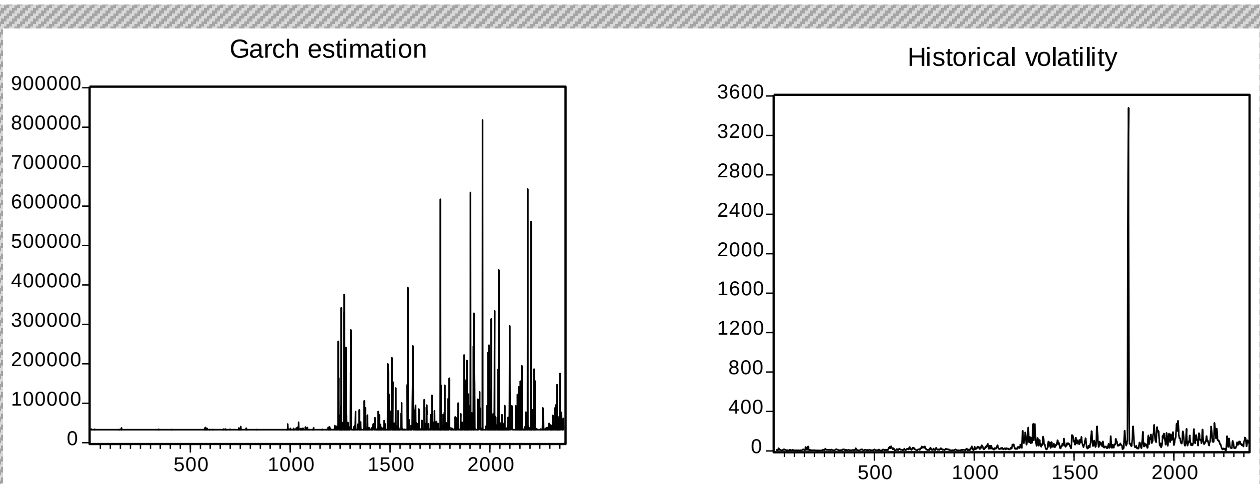
	Coefficient	Std. Error	z-Statistic	Prob.
AR(1)	1.003141	0.000368	2724.508	0.0000
GED PARAMETER	0.795548	0.049231	16.15953	0.0000
R-squared	0.999246	**Mean dependent var**		3968.253
Adjusted R-squared	0.999244	**S.D. dependent var**		3089.738
S.E. of regression	84.96315	**Akaike info criterion**		11.65010
Sum squared resid	17057874	**Schwarz criterion**		11.66714
Log likelihood	-13798.37	**Durbin-Watson stat**		1.712596



the market presents some evidences of "weak" form of informational efficiency but more detailed investigations are necessary to conclude for the "semi-strong" and "strong" forms.

The *PARCH* empirical parameters are reported in *Table 5*. These parameters have been estimated by involving an *ML - ARCH (Marquardt)* methodology with a *Generalized error distribution* (GED) term. It could be observed that the autoregressive parameter is highly statistically relevant and overall the model provides a good description of the index evolution.

In *Graphic 1* are presented the *PARCH* volatility estimation



Graphic 1. PARCH and historical volatility

Table 6
***Quandt-Andrews unknown breakpoint test* for PARCH estimated volatility**

Null Hypothesis: No breakpoints within trimmed data
Equation Sample: 3 2371
Test Sample: 357 2013
Number of breaks compared: 1657

Statistic	Value	Prob.
Maximum LR F-statistic (Observation 26.01.2005)	155.8058	0.0000
Exp LR F-statistic	70.51793	0.0000
Ave LR F-statistic	88.52650	0.0000

Note: probabilities calculated using Hansen's (1997) method

together with the baseline of the historical *volatility* (with the lag *m* set to 5). The shape of these two volatility estimators displays important "peaks" suggesting the existence of some structural changes in their inner mechanisms. For identifying the "breaking points" in the volatility evolution, a *Quandt-Andrews Breakpoint Test* is applied on *PARCH* volatility estimation (*Table 6*). The results of the test suggest that the evolution of the volatility could be spited in at least two sub-periods: a first one between May 2000 and end of January 2005 and, respectively, the last one between February 2005 and June 2009. Such an empirical result supports the more broader conclusions that could be derived about the end of 2005 as a major shifting point in the market mechanisms, increased uncertainty and deterioration of the financial stability.

4. Conclusions and Further Research

The *PARCH* class of GARCH models provides an interesting framework able to capture some aspects of the volatility evolution. In the case of Romanian capital markets, the advanced analysis could support some partial conclusions. Among them:

1) The market volatility was substantial modified starting with the end of 2005 as a consequence of an increased uncertainty, capital outflows and the pessimistic expectations of both domestic and foreign investors;
2) As a consequence, the capacity of the market to absorb endogenous and exogenous financial, real and informational shocks was diminishing significantly.

Naturally, such conclusions should be considered with extreme prudence since their validity depends on the volume and data accuracy as well as on the intrinsic limits of the analytical framework. However, even this limited analysis could enlighten the necessity of more profound studies of the recent evolution of the Romanian capital market.

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