RECENT CHANGES ON ROMANIAN CAPITAL MARKET'S VOLATILITY IN THE FRAMEWORK OF A *COMPONENT GARCH* MODEL

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ABSTRACT: The Romanian capital market was receiving the shock waves of the financial crisis starting with August 2007. The volatility of its evolutions was corresponding modified as a response to an increased uncertainty trading environment. The objective of this paper is to provide some empirical evidences for a more detailed analysis of these changes by employing a „Component GARCH" model. The main output consists in the finding that both long-run and short-run components of the volatility were affected by structural changes.

Key words: Romanian capital market, financial crisis, Component GARCH, long-run volatility, short-run volatility

JEL codes: G10,G15

Introduction

During the last decades a lot of empirical studies have analyzed the capital markets crises, their causes and implication, the way one could forecast them in order to take all the needed action to reduce the potential damages. Detailed analysis of some of the evolutions in the emergent capital markets from Central and Eastern Europe could be seen in Claessens,S., Klingebiel,D. and Schmukler,S[2002], Koke,J and Schroder,M[2003]. Ricardo J. Caballero and Arvind Krishnamurthy [2005] consider that emerging market economies (EM's) are plagued by episodes of bubble-like dynamics. These episodes begin with a "bubble" phase where credit, investment, asset prices, and capital inflows, all grow, and end with a bust phase when these variables collapse. One view of emerging markets crises – Furman and Stiglitz [1998], Calvo [1998], Caballero and Krishnamurthy [2001], Chang and Velasco [2001] – describes normal times as periods with significant capital inflows, which are suddenly interrupted by liquidity crises. Caballero and Krishnamurthy (2005) have a different view. Normal times are those with net capital outflows. These normal periods are occasionally interrupted by speculative bubbles, which can crash. Moreover, we show that in many instances these bubbles, while rational, are socially inefficient since they introduce excessive aggregate fragility.

Volatility increases after stock prices fall; it increases during recessions and also around major financial crises (Schwert[1989]). Also Hamilton and Lin [1996] suggest that volatility in the stock market may prove usefull in forecasting the future trend in real economic activity. Choe, Masulis and Nanda [1993] provide empirical evidence showing that the corporate use of external financing depends on market volatility. Pyndick and Solimano [1993] find that volatility (of the marginal productivity of capital) reduces the rate of investment for a panel of LDC countries, but not for a panel of OECD countries (decade average observations of 1960s, 1970s, 1980s). Nico Valcks, Marc J. K. de Ceuster and Jan Annaert [2002] show that interest rate and stock market volatility add some explanatory power, to predict future recessions or real growth. They prove that the yield spread and real stock returns are useful to predict recessions over monthly horizons and that financial market volatility could play an extra roll to signal recessions.

Starting from these studies the paper tries to analyze the Romanian capital market in the framework of the recent evolutions on the international capital markets, in terms of volatility. In this context the second part of the paper presents some defining elements of the latest evolutions of the Romanian capital market. In part three the empirical evidences in order to justify the thesis that the financial crises are a determinant factor of the changes in the volatility of the Romanian capital market' evolution are provided. The fourth part is designated to the conclusions.

2. Romanian capital market – evolutions and tendencies

One could see that even if the Romanian capital market has generally known an positive development between the years 2002-2007, managing to get ahead of well known emergent markets, such as: Russia, China, Egypt or Brazil, in terms of capital market efficiency and growth (Standard Poor's Agency Report shows a 69,7% growth during the 2002-2006) its size remains a modest one. Studying the Romanian capital market evolution, more exactly the Bucharest Stock Exchange evolutions (BSE), one could reveal the existence of some 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 falling stopped and the BSE started to develop a long term solid foundation. After 2000 the evolution of the BSE was relatively favourable with a high peak in 2004-2005 (in 2005 the holdings limit for the Financial Investments Societies had increased and the largest Romanian bank was privatised) and in august 2007. The lowest point was reached in 2006 when the BET index had the smallest return in the last six years.

During the last years, a permissive set of rules, cheap money and the more and more growing competition in the financial sector have led to the actual global financial crisis. The fears regarding the United States recession and the evolution of international markets led to the crash of Bucharest Stock Exchange quotes at the middle of October 2008 in the framework of an already existing descending trend at Bucharest Stock Exchange. If one looks at the main causes of the volatility in the last decade (a strong emotional status which overwhelms the main stream of the investors due to the existence of some positive factors – sentiments of euphoria, joy, greed – or some negative factors – sentiments of apathy, risk aversion, fear or even panic; the globalization of the capital markets) and analyses the last crises evolution is easy to notice the presence of both main factor of volatility and of course of their results.

3. Empirical evidences

The purpose of this section is to examine some possible evidence for the thesis that the volatility of the Romanian capital market' evolution was recently changes under the impact of financial crisis. This evolution is synthesized by the BET-C the market composite index. BET-C is a market capitalization weighted index. BET-C reflects the price movement of all the companies listed on the Bucharest Stock Exchange regulated market, 1st and 2nd category, excepting the SIFs. It could be supposed that the index evolution could be satisfactory described as a stochastic process so that it's dynamic could be estimated like:

$$y_t = \ln\left(\frac{Y_t}{Y_{t-1}}\right) * 100 \qquad (1)$$

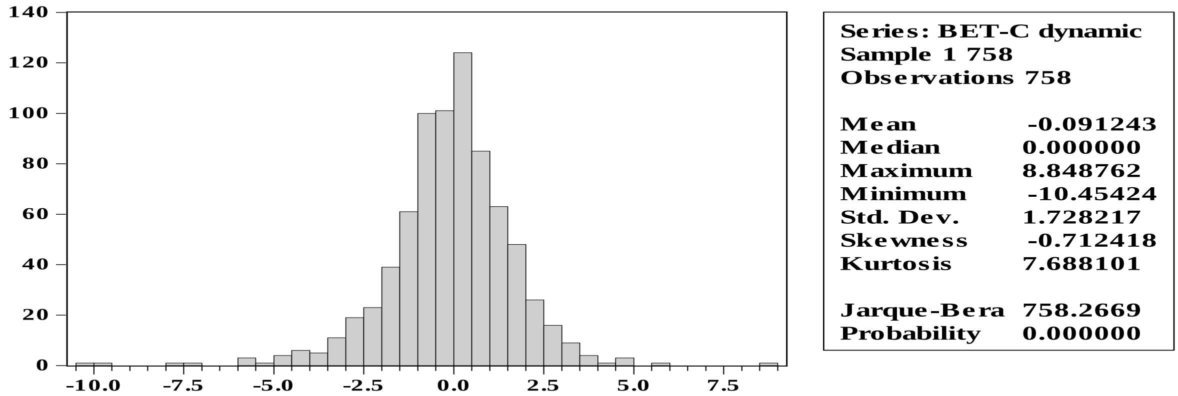

Fig. no. 1 – The general statistics of the BET-C dynamic

Table No.1

The stationarity tests for BET-C variations

I. Augmented Dickey-Fuller Unit Root test

Null Hypothesis: The dynamic of BET-C has a unit root
Exogenous: Constant
Lag Length: 19 (Automatic based on Modified HQ, MAXLAG=19)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		**-3.090752**	**0.0277**
Test critical values:	**1% level**	-3.438984	
	5% level	-2.865240	
	10% level	-2.568796	

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

II. Phillips-Perron

Null Hypothesis: LNBETC has a unit root
Exogenous: Constant
Lag length: 6 (Fixed Spectral GLS-detrended AR)

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		**-35.23113**	**0.0000**
Test critical values:	**1% level**	-3.438762	
	5% level	-2.865143	
	10% level	-2.568744	

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

Residual variance (no correction)	2.948284
HAC corrected variance (Spectral GLS-detrended AR)	0.309674

The histogram of the BET-C' dynamic as well as the stationarity tests indicates that:

- The changes in the index level does not displays a "normal" distribution with important *fat-tails* effects;
- Despite some minor differences between the two tests overall both of them concludes that the index' dynamic could be described as a $I(0)$ ("stationary") process.

In order to identify the cyclical behavior of the market index there could be employed the techniques of the *band-pass* (frequency) filters. These filters are used to isolate the *cyclical* component of a time series by specifying a range for its duration. The band-pass filter is a linear filter that takes a two-sided weighted moving average of the data where cycles in a "band", given by a specified lower and upper bound, are "passed" through, or extracted, and the remaining cycles are "filtered" out. Full sample asymmetric is the most general filter, where the weights on the leads and lags are allowed to differ. The asymmetric filter is time-varying with the weights both depending on the data and changing for each observation. For instance, a *full sample asymmetric Christiano-Fitzgerald* filter generates the next decomposition for BET-C:

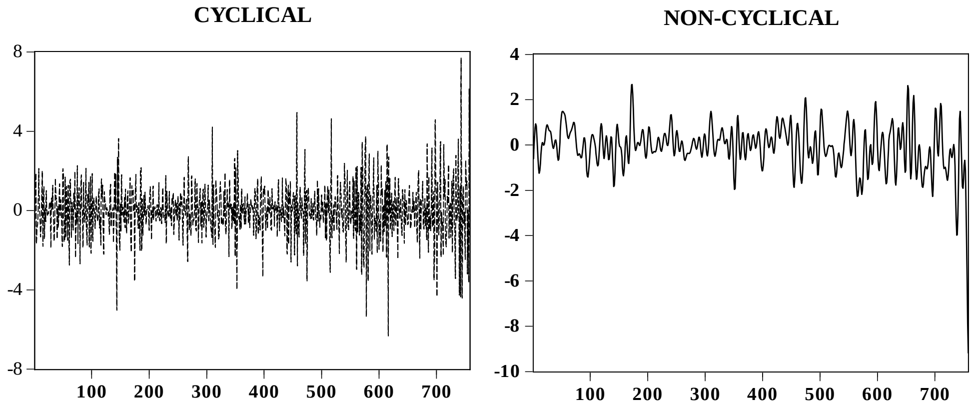

Fig. no. 2 – The BET-C index dynamic' components

It could be observed that the filter provides the image of at least five areas with a relative different pattern in the cyclical / non-cyclical components of the index dynamic, areas delimited by "spikes" in these components. So there it could be presumed the existence of some structural transformations in the market mechanisms.

A more detailed analysis for the index volatility could be provided in the framework of a *Component GARCH* model. The *Autoregressive Conditional Heteroskedasticity* (ARCH) models are specifically designed to model and forecast conditional variances. The variance of the dependent variable is modeled as a function of past values of the dependent variable and independent or exogenous variables.

So it could be noticed that the *conditional variance* in the simplest GARCH (1, 1) model:

$$\sigma^2{}_t = \varpi + \alpha\left(\varepsilon^2{}_{t-1} - \varpi\right) + \beta\left(\sigma^2{}_{t-1} - \varpi\right) \qquad (2)$$

shows mean reversion to ϖ , which is a constant for all time. By contrast, the *component model* allows mean reversion to a varying level m_t , modeled as:

$$\begin{aligned} y_t &= x'_t \pi + \varepsilon_t \\ m_t &= \omega + \rho\left(m_{t-1} - \omega\right) + \varphi\left(\varepsilon^2{}_{t-1} - \sigma^2{}_{t-1}\right) \\ \sigma^2{}_t - m_t &= \alpha\left(\varepsilon^2{}_{t-1} - m_{t-1}\right) + \beta\left(\sigma^2{}_{t-1} - m_{t-1}\right) \qquad (3) \end{aligned}$$

Here $\sigma^2{}_t$ is still the volatility, while m_t takes the place of ϖ and is the time varying *long-run volatility*. The third equation describes the *transitory component*, $\sigma^2{}_t - m_t$, which converges to "zero" with powers of $(\alpha + \beta)$. The second equation describes the *long run* component m_t, which is convergent to ω with powers of ρ. ρ is typically between "0.99" and "1" so that m_t approaches ω very slowly. We can combine the *transitory* and *permanent* equations and obtain:

$$\sigma^2{}_t = (1-\alpha-\beta)(1-\rho)\omega + (\alpha+\varphi)\varepsilon^2{}_{t-1} - [\alpha\rho + (\alpha+\beta)\varphi]\varepsilon^2{}_{t-2} + (\beta-\varphi)\sigma^2{}_{t-1} - \\ - [\beta\rho - (\alpha+\beta)\varphi]\sigma^2{}_{t-2} \qquad (4)$$

which shows that the component model is a (nonlinear) restricted **GARCH(2, 2)** model.

The variables in the transitory equation will have an impact on the *short run* movements in volatility, while the variables in the permanent equation will affect the *long run* levels of volatility.

Table No.2

The Component GARCH model empirical parameters for the BET-C index

Dependent Variable: BET-C variation
Method: ***ML - ARCH (Marquardt) - Generalized error distribution (GED)***
Sample: 1 758
Included observations: 758
Convergence achieved after 106 iterations
Pre-sample variance: backcast (parameter = 0.7)
Q = C(1) + C(2)(Q(-1) - C(1)) + C(3)*(RESID(-1)^2 - GARCH(-1))*
*GARCH = Q + C(4) * (RESID(-1)^2 - Q(-1)) + C(5)*(GARCH(-1) - Q(-1))*

	Coefficient	**Std. Error**	**z-Statistic**	**Prob.**
	Variance Equation			
C(1)	14.83730	142.1931	0.104346	0.9169
C(2)	0.999597	0.004664	214.3100	0.0000
C(3)	0.019799	0.013607	1.455046	0.1457
C(4)	0.209360	0.060140	3.481182	0.0005
C(5)	0.573404	0.131797	4.350671	0.0000
GED PARAMETER	1.369923	0.098210	13.94888	0.0000
R-squared	-0.002791	**Mean dependent variable**		-0.091243
Adjusted R-squared	-0.009459	**S.D. dependent variable**		1.728217
S.E. of regression	1.736371	**Akaike info criterion**		3.684424
Sum squared residuals	2267.268	**Schwarz criterion**		3.721078
Log likelihood	-1390.397	**Hannan-Quinn criterion**		1.732432

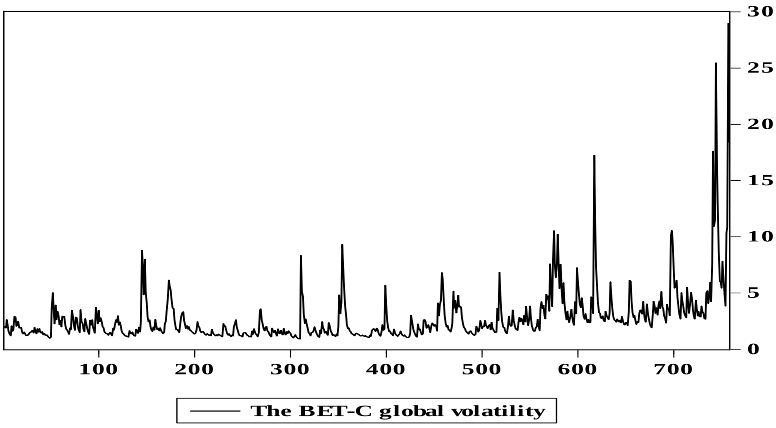

Fig. no. 3 – The global volatility of the BET-C index

The global volatility of the index' dynamic estimated in this framework enlighten that the entire time span of analysis it is in fact structured the next sub-periods: (a) October 2005- January 2006; (b) January 2006- March 2007; (c) March 2007- August 2007; (d) August 2007- March 2008; (e) March 2008- October 2008 each of them with its distinctive characteristics.
As a further analytical step, the global volatility could be decomposed in a *long-term* component and, respectively, in a *short-term* one:

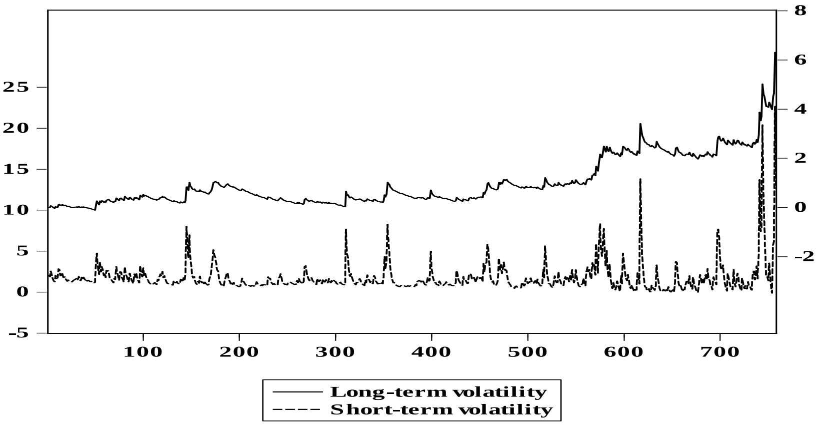

Fig. no. 4 – The components of the index volatility

It could be noticed the fact that after a relatively smooth evolution the amplitude of the *long-run* component of volatility is increasing in the part of the time interval. The same evolution is characteristic for the *short-run* component. This could reflect that in the conditions of a higher degree of uncertainty the market operators adjust more frequently the structure of their portfolio and the *bid/ask* book is changing more rapidly.

Also the estimated *long-run* volatility could be used for isolating the "structural breaking points" (the areas of changes in the volatility mechanisms).

As a first step, the evolution of this component is described inside as framework of an *AR* equation:

$$y_t = \alpha y_{t-1} + \varepsilon_t \quad (5)$$

For estimating the probability of "structural breaking points" the equation parameters stability over the observation sample is analyzed by involving a specific test, the Quandt-*Andrews*

Breakpoint Test one. These tests for one or more unknown structural breakpoints are the sample for a specified equation. The idea behind the *Quandt-Andrews test* is that a single *Chow Breakpoint Test* is performed at every observation between two observations, τ_1 and τ_2. The k test statistics from those *Chow* tests are then summarized into one test statistic for a test against the null hypothesis of no breakpoints between τ_1 and τ_2 . The individual test statistics can be summarized into three different statistics: the *Sup or Maximum* statistic, the *Exp Statistic*, and the *Ave* statistic (see [Andrews, 1993] and [Andrews and Ploberger, 1994]).

The results look like follows:

Table no. 3

The stability test for the long-run component of BET-C volatility

Quandt-Andrews unknown breakpoint test
Null Hypothesis: No breakpoints within trimmed data
Equation Sample: 2 758
Test Sample: 115 643
Number of breaks compared: 529

Statistic	Value	Prob.
Maximum LR F-statistic (Observation 644)	2.951948	0.5640
Exp LR F-statistic	0.559482	0.3969
Ave LR F-statistic	1.038262	0.3262

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

These results suggest that May 2007 could be seen as a major area of structural changes in market volatility.

An alternative approach consists in running an *AR* model with time-varying parameters over the *long-time* component and examines the changes in these parameters:

$$y_t = \alpha_t y_{t-1} + \beta_t y_{t-2} + \gamma_t$$
$$\gamma_t = \gamma_{t-1} + \varepsilon_t \qquad (6)$$

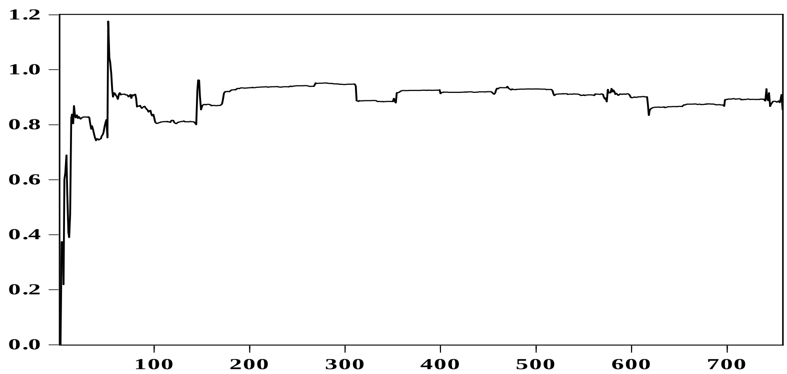

Fig. no. 5 – The AR (1) time-varying autoregressive parameter

The shifting in the level of AR (1) tends to isolates more or less the same already mentioned period’s specific for the evolution of the *long-run* volatility component.

4. Conclusions and further research

The Component GARCH *model* provides a complex analytical framework in which the volatility of Romanian capital market index’ dynamic could be analyzed. In this framework some (partial) conclusions could be formulated: (1) The dynamic' volatility suffers some „structural changes" over the time span as a consequences of the market mechanisms' transformation; (2) Such transformations affects both the *long-run* as well the *short-run* components of the volatility. In other words, the exogenous shocks are not completely absorbed in „one period" but are reverberated over the „long time" expectations of the market operators. If there is presumed a relative stable „profile at risk" for these operators' decisions this implies that they tends to formulate more often a „pessimistic" anticipation of the market evolution. Of course, such conclusions should be explained with extreme prudence since their validity depends on the volume and data accuracy as well as on the *ARCH* class of models considered. But despite these *caveats* it seems that the empirical evidences support the thesis that the predominant „feeling of the market" is characterized by uncertainty and anxiety about the aftermath of the financial crisis.

References:

1. Andrews, D. W. K.,*Tests for Parameter Instability and Structural Change With Unknown Change Point*, Econometrica, 61(4), 821–856,1993

2.Andrews, D. W. K, Ploberger W., *Optimal Tests When a Nuisance Parameter is Present Only Under the Alternative*, Econometrica, 62(6), 1383–1414,1994

3. Bollerslev, T, R. ,Chou, Y, Kroner,K.,F, *ARCH Modeling in Finance: A Review of the Theory and Empirical Evidence*, Journal of Econometrics, 52, 5–59, 1992

4. Caballero, R.J., Krishnamurthy, A, *International and Domestic Collateral Constraints in a Model of Emerging Market Crises*, Journal of Monetary Economics 48, 513-548, 2001

5. Caballero, R.J. and Krishnamurthy, A., *Bubbles and Capital Flow Volatility: Causes and Risk Management*, Working Paper 05-20 Cambridge, August 25, 2005.

6. Calvo, G.A., *Balance of Payment Crises in Emerging Markets*, mimeo, Maryland, January 1998.

7. Chang, R., Velasco, A., *A Model of Financial Crises in Emerging Markets*, Quarterly Journal of Economics, Volume 116, No. 2 , May 2001.

8.Choe, H., Masulis R. W., Nanda, V., *Common Stock Offerings across the Business Cycle: Theory and Evidence*, Journal of Empirical Finance, 3-31, 1993.

9.Claessens,S.,Klingebiel,D. and Schmukler,S.- *Explaining the migration of stocks from exchanges in emerging economies to interational centres,*CEPR Discussion Paper no.3301/2002 www.cepr.org/pubs/dps/DP3301.asp

10. Ding, Z, Granger, C. W. J., Engle, R. F, "*A Long Memory Property of Stock Market Returns and a New Model*, Journal of Empirical Finance, 1, 83–106, 1993

11. Furman, J. , Stiglitz J., *Economic Crises: Evidence and Insights from East Asia*, Brookings Papers of Economic Activity, vol. 2, 1998

12. Glosten, L. R., R. Jaganathan,. Runkle, D, *On the Relation between the Expected Value and the Volatility of the Normal Excess Return on Stocks*, Journal of Finance, 48, 1779–1801,1993

13.Hamilton, J. D., Lin, G., *Stock Market Volatility and the Business Cycle*, Journal of Applied Econometrics, 11 (5), 1996

14. Koke,J and Schroder,M. –The prospects of capital markets in central and Eastern Europe, ZEW Discussion paper no.02-57/2003

15.Pindyck, R.S., Solimano, A., *Economic Instability and Aggregate Investment,* NBER Macroeconomics Annual, Vol. 8, 1993.

16. Schwert, G.W., *Business Cycle, Financial Crises and Stock Volatility*, Carnegie-Rochester Conference Series on Public policy, 31 (0), 1989.

17. Valcks N., de Ceuster, M. J. K., Annaert, J., *Is Financial Market Volatility Informative to Predict Recessions?*, DNB Staff reports, No.93, 2002.

18. Zakoïan, J. M., *Threshold Heteroskedastic Models*, Journal of Economic Dynamics and Control, 18, 931-944, 1994.