Modeling Risk Convergence for European Financial Markets

Radu LUPU, PhD
Institute for Economic Forecasting, Romania

Adrian Cantemir CALIN, PhD
Institute for Economic Forecasting, Romania,
cantemircalin@ipe.ro

Iulia Lupu, PhD
"Victor Slăvescu" Centre for Financial and Monetary Research, Romanian Academy.

Oana Cristina Popovici, PhD
Institute for Economic Forecasting, Romania

Abstract: This article studies the convergence of risk on a sample of 13 European indexes. We use a set of 31 model specifications of a significant number of models belonging to the GARCH class and on their estimates we build an aggregate index in a Value-at-Risk approach. We use this index as a base for our convergence analysis. The results indicate a positive and significant tendency of convergence growth for the European financial market.

Keywords: convergence, financial risk, Value-at-Risk, European Financial Markets

JEL classification C58, G17, G15

1. Introduction

Lately, the convergence of international financial market has become an area of interest fot the academic literature. This wave of interest is associated to financial globalization which contributed to the exclusion of restrictions on financial transactions, harmonization of regulatory frameworks and accounting procedures and the propagation of foreign direct investments. These phenomena accelerated the international flows of capital which theoretically lead to a higher degree of convergence agmong international financial markets.

Financial convergence was intensively studied, both at a global level, and from the perspective of the European Union especially given the efforts of the EU in obtaining a higher degree of fiancial armonization among member states.

In this paper we aim to extend the existing literature by studying and assessing the degree of risk convergence present on the European financial markets. In a volatility oriented approach we use a relevant set of GARCH models as preliminary elements in the construction of an index on which we conduct our convergence investigation.

The remainder of the paper is organized in the following manner. Section II offers a brief review of the literature. Section III is dedicated to a discussion on the data employed and on the methodological aspects relevant to this study. The final section presents the results obtained and concludes.

2. Literature review

As stated before, the study of the convergence of financial markets has been an active topic of the academic community. Arouri (2004) and Jayasuriya and Shambora (2008) investigate the returns gained by US investors involved in transactions in emerging markets. The authors report a diminishing tendency of the levels of returns which can be traced back to an enhancement of the degree of market convergence.

Hartmann et al (2003) state that the degree of integration and convergence of international markets reduces significantly the diversification potential, from the point of view of a portfolio. Similar evidences have been put forward by Baca *et al.* (2000) or Ferreira (2004).

The financial integration in the EU is a captivating area of research, receiving attention from both academics and investors. Despite certain elements like the building of a single market, the relaxation of some national regulation, policies encouraging financial integration and the introducing of the Euro, the scientific literature has observed that the European markets are still less homogenous than the US market. (Carporale et al, 2014).

Hardouvelis et al. (2007) report a correlation between the reduction of the cost of capital and the growth of financial convergence in Europe. Similar results are observed by Chen and Knez (1995) and Fratzscher (2002) in arbitrage based approaches. Baele *et al.* (2004), and Portes and Rey (2005) provide ample studies that bring evidence of the influence of the Euro currency in the convergence of the equity market. Horobet and Lupu (2005) also provides an analysis of the connections between currencies and stock market performance, which could be considered in the wider framework of the importance of foreign exchange for the convergence of financial markets in general.

Contrasting results are presented by Brooks and Del Negro (2004). The authors state that the correlations observed among national financial markets are only a temporary aspect enabled by the development of the IT sector.

In an interesting approach from the point of view of our study, Ferreira and Gama (2005) advance a system of volatility decomposition that allows the study of equity volatility from an international, national and local perspective.

The scientific literature addresses the convergence phenomenon on markets that exceed the European space. For example, in the case of Asian markets, Piesse and Hearn (2002) and Cerny (2004) determine a very weak level of convergence. On the other hand, Yang *et al.* (2003), report that this inadequate tendency is only valid for the period following the Asian crisis.

Some scientific studies focus on the North American markets. Darrat and Zhong (2005) and Aggarwal and Kyaw (2005) study convergence related aspects for the NAFTA member states. Other similar results can be found in Ciner (2006), Chukwuogor-Ndu (2007) and Chukwuogor-Ndu and Kasibhatla (2007).

Apergis et al (2014) and Caporale et al (2014) extend the convergence methodology developed by Phillips and Sul (2007) in order to study the convergence of stock markets. In another recent contribution, Albu, Lupu and Calin (2014) investigate the connection between market capitalization and GDP per capita through a convergence based approach. The authors put forward a non-linear model that simulates the convergence in Central and Eastern Europe and apply it to both macroeconomic variables and market capitalization.

3. Methodology and data sources

In this study we used daily prices for a series of 13 European indexes. Thus, we collected values for the following indexes: BEL20 Index, BET Index, BGTR30 Index, BUX

Index, CAC Index, DAX Index, FTSEM Index, FTSEMIB Index, IBEX Index, PSI20 Index, PX Index, UKX Index, and WIG Index. The data were gathered for a period ranging from January 2005 to November 2014. In order to achieve our objectives, the methodology used is organized in three stages. The first stage is dedicated to the estimation of the volatility with an extensive arsenal of GARCH models. In the second phase we construct a volatility index on the basis of the above mentioned estimations. The final stage of our methodology aims to estimate the volatility convergence.

Stage 1. Volatility models

In the following section we briefly review the volatility models used in this analysis. These models are validated by the scientific literature and are capable of capturing the statistical properties of the data series. For a detailed discussion on GARCH modeling see for example Călin et al. (2014) or Lupu and Lupu (2009). Other relevant results using GARCH models have been reported by Albu et al (2014a), Albu et al (2014b), Horobet et al (2011).

The first instrument used of the estimation of the volatility is the classical GARCH modeling background.

$$R_t = \mu_t + \epsilon_t \quad (1)$$
$$\sigma_t^2 = \omega + \alpha_1 \epsilon_{t-1}^2 + \alpha_2 \epsilon_{t-2}^2 + \ldots + \alpha_P \epsilon_{t-P}^2 \quad (2)$$

One of the most relevant extension of the GARCH model from the perspective of risk modeling appeared through the study of Nelson (1991). The EGARCH model - *Exponential Generalized Autoregressive Conditional Heteroskedasticity* is able to capture an interesting feature of the financial assets, namely the presence of a dose of asymmetry different from zero. The general form of the model is:R

$$R_t = \mu_t + \epsilon_t \quad (3)$$
$$ln(\sigma_t^2) = \omega + \sum_{p=1}^{P} \alpha_p \left(\left| \frac{\epsilon_{t-p}}{\sigma_{t-p}} \right| - \sqrt{\frac{2}{\pi}} \right) + \sum_{0=1}^{O} \gamma_o \frac{\epsilon_{t-o}}{\sigma_{t-o}} + \sum_{q=1}^{Q} \beta_q ln(\sigma_{t-q}^2) \quad (4)$$

The GJR-GARCH model (*Glosten - Jagannathan - Runkle Generalized Autoregressive Conditional Heteroskedasticity*) extends the classic GARCH specification by adding the possibility to capture asymmetric properties such as the leverage effect. The GJR-GARCH (Glosten et al (1993)) is defined by the following set of equations:

$$R_t = \mu_t + \epsilon_t \quad (5)$$
$$\sigma_t^2 = \omega + \sum_{p=1}^{P} \alpha_p \epsilon_{t-p}^2 + \sum_{o=1}^{O} \gamma_o \epsilon_{t-o}^2 I_{[\epsilon_{t-o}<0]} + \sum_{q=1}^{Q} \beta_q \sigma_{t-q}^2 \quad (6)$$

The APARCH model (*Asymmetric Power Generalized Autoregressive Conditional Heteroskedasticity*) refines the GJR-GARCH having basically the same objective. The model established by Ding, Engle and Granger (1993) has the following form

$$R_t = \mu_t + \epsilon_t \quad (7)$$

$$\sigma_t^\delta = \omega + \sum_{j=1}^{max(P,O)} \alpha_j(|\epsilon_{t-j}| + \gamma_j\epsilon_{t-j})^\delta + \sum_{q=1}^{Q} \beta_q\sigma_{t-q}^\delta \quad (8)$$

The ZARCH model is an approach that allows the standard deviation to depend on the sign of past invocations. The model was put forward by Zakoian in 1994 and is better known in the scientific literature as TARCH or TGARCH.

$$R_t = \mu_t + \epsilon_t \quad (€15)$$

$$\sigma_t = \omega + \sum_{p=1}^{P} \alpha_p|\epsilon_{t-p}| + \sum_{o=1}^{O} \gamma_o|\epsilon_{t-o}|I_{[\epsilon_{t-o}<0]} + \sum_{q=1}^{Q} \beta_q\sigma_{t-q} \quad (9)$$

The NAGARCH model developed by Engle and Ng (1994) is know in the specific literature as the *Nonlinear GARCH*. This model assumes a non-linear depends between the standard deviation and the sign of anterior shocks. The general form of the model is the following:

$$R_t = \mu_t + \epsilon_t \quad (€18)$$

$$\sigma_t = \omega + \sum_{p=1}^{P} \alpha_p(\epsilon_{t-p} - \gamma\sqrt{\sigma_{t-p}})^2 + \sum_{q=1}^{Q} \beta_q\sigma_{t-q} \quad (10)$$

The IGARCH - *Integrated GARCH* (Engle and Bollerslev (1986) extends the GARCH family by allowing a non-stationary dynamics to the standard deviation. The specification of the model is:

$$R_t = \mu_t + \epsilon_t \quad (€21)$$

$$\sigma_t^2 = \omega + \sum_{p=1}^{P} \alpha_p(\epsilon_{t-p})^2 + \sum_{q=1}^{Q} \beta_q\sigma_{t-q}^2 \quad (11)$$

The last model considered in our study was introduced by Baillie et al. (1996) and it is called FIGARCH (*Fractionally Integrated GARCH*).

$$R_t = \mu_t + \epsilon_t \quad (12)$$

$$\sigma_t^2 = \omega + (1 - \beta L - \phi L(1 - L)^d)\epsilon_t^2 + \beta\sigma_{t-1}^2 \quad (13)$$

According to the mathematical aspects presented above, we calibrated a series of specifications for each model:

- For the GARCH model we calibrated the following specifications: GARCH (1,1), GARCH (1,2), GARCH (2,1) and GARCH (2,2)
- For the EGARCH model we calibrated the following specifications EGARCH (1,1,1), EGARCH (1,1,2), EGARCH (2,2,1) and EGARCH (2,2,2).
- For the GJR-GARCH model we calibrated the following specifications GJR-GARCH (1,1,1), GJR-GARCH (1,1,2), GJR-GARCH (2,2,1) and GJR-GARCH (2,2,2)
- For the APARCH model we calibrated the following specifications APARCH (1,1,1), APARCH (1,1,2), APARCH (2,2,1) and APARCH (2,2,2).
- For the ZARCH model we calibrated the following specifications ZARCH (1,1,1), ZARCH (1,1,2), ZARCH (2,2,1) and ZARCH (2,2,2)
- For the NAGARCH model we calibrated the following specifications NAGARCH (1,1), NAGARCH (1,2), NAGARCH (2,1) and NAGARCH (2,2)
- For the IGARCH model we calibrated the following specifications IGARCH (1,1), IGARCH (1,2), IGARCH (2,1) and IGARCH (2,2)

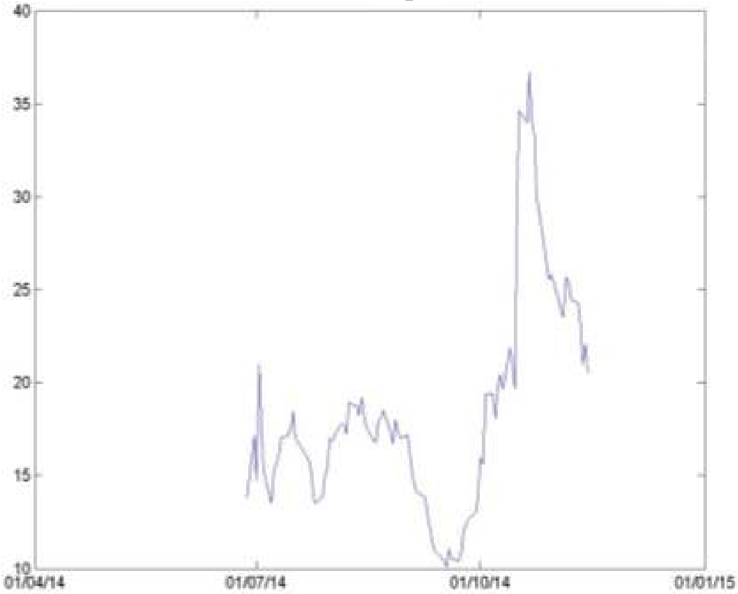
- For the FIGARCH model we calibrated the following specifications FIGARCH (1,1), FIGARCH (0,1) and FIGARCH (1,0).

In total, during this phase we calibrate 31 models in order to capture the volatility of the 13 European indexes.

Stage2: Constructing an aggregate index for the volatility of the European market

During this phase we calculated an aggregate index using the entire sample of mathematical models described and calibrated in the previous section. The volatility index represents a measure of the risk and uses all the financial assets included in this study. The relevance of this index derives from its capacity to describe a clear image of the risk specific to the European financial market. The dynamic of this index is presented in Figure 1.

Figure 1: The dinamics of the volatility index for the 13 financial indexes and for all the models constructed in the previous section



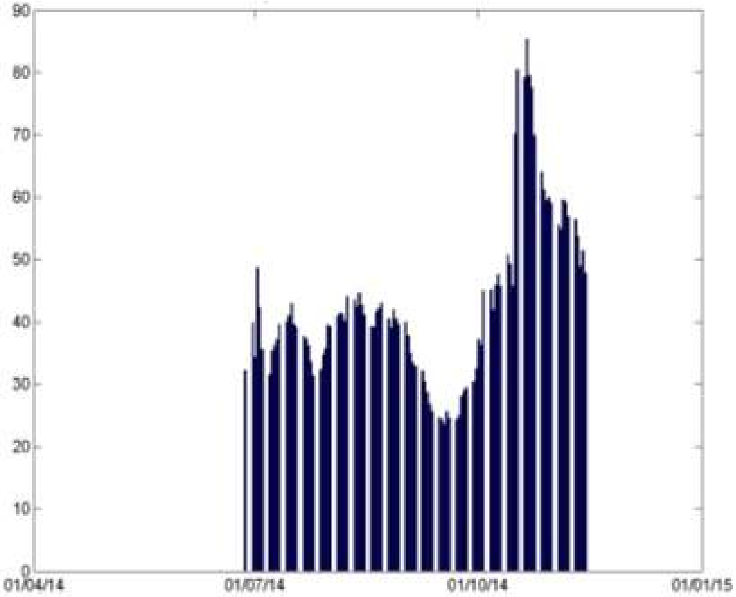
Source: Authors' work

Technically, financial indexes have the role of informing the general public about the nature and evolution of the financial assets traded on a capital market and to serve as guidelines in investing strategies.

In order to achieve our objective for this section we computed the (Value-at-Risk) indicators for each asset considered in this study. From this construction we continued with the calculation of the aggregate index and with the characterization of the financial market in terms of volatility.

Conceptually, the Value-at-Risk derives from the need of a stable indicator that can describe the risk for a certain investment. Statistically, VaR represents a probabilistic measure of a potential loss. The evolution of the aggregated VaR is shown in Figure 2.

Figure 2: The evolution of VaR of the capital market composed by the chosen indexes



Source: Authors' work

Stage 3. Modeling the convergence analysis

In order to assess the convergence of volatility we studied the macroeconomic model advanced by Kočenda and Papell (1997) and extended by Albu, Iordan and Lupu (2012). We translated the logic of the model towards the measures of risk on the European financial market.

Kočenda and Papell (1997) consider the existence of a group of countries and a series of values. Assuming X to be the growth rate of a variable, the authors derive the average for each moment by computing the following equation.

$$\overline{X_t} = \frac{1}{n}\sum_{i=1}^{n} X_i \quad (14)$$

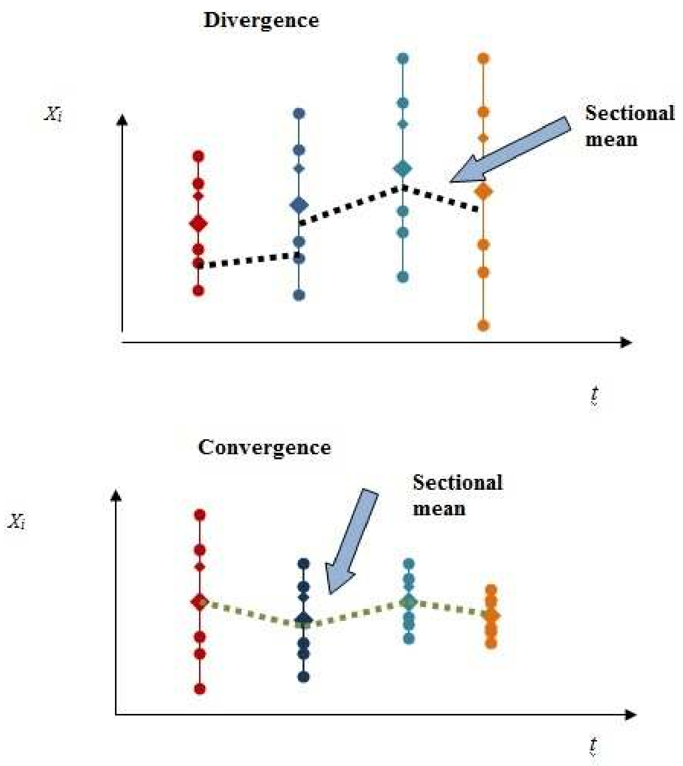
The next step involves the calculation of the distances:

$$\mathrm{d}_{\mathrm{i,t}} = \mathrm{X}_{\mathrm{i,t}} - \overline{X_t} \quad (15)$$

The economic theory states that in the case of convergence, the above mentioned distance should decrease, in the sense that the values of *X* should tend towards the values of the group.

Symmetrically, in the situation of divergence, the results will indicate a growth of the distance values. The logic of the methodology is summarized in Figure 3.

Figure 3. Divergence and convergence



Source: Adaptation of Albu et al (2012) for volatilities

Kočenda and Papell (1997) state that *X* follows an AR(1) process

$$\mathrm{X}_{\mathrm{i,t}} = \alpha + \phi X_{i,t-1} + \epsilon_{i,t} \quad (16)$$

In this context, the dynamics of the sectional average is described by the relation:

$$\overline{X_t} = \alpha + \phi\overline{\mathrm{X}}_{t-1} + \epsilon_{i,t} \quad (17)$$

From this moment, the evolution of the difference is given by the following equations.

$$\mathrm{d}_{\mathrm{i,t}} = X_{i,t} - \overline{X_t} = \phi\left(X_{i,t-1} - \bar{X}_{t-1}\right) + \epsilon_{i,t} \quad (18)$$

$$\mathrm{d}_{i,t} = d_0 e^{-rt} \quad (19)$$

$$\mathrm{d}_{i,t+1} = X_{i,t+1} - \bar{X}_{t+1} = \phi\left(X_{i,t} - \bar{X}_t\right) + \epsilon_{i,t+1} = d_0 e^{-r(t+1)} \quad (20)$$

$$\mathrm{d}_{i,t} = X_{i,t} - \bar{X}_t = \phi\left(X_{i,t-1} - \bar{X}_{t-1}\right) + \epsilon_{i,t} = d_0 e^{-rt} \quad (21)$$

$$\phi\left(\mathrm{X}_{i,t-1} - \bar{X}_{t-1}\right) = d_0 e^{-rt} \quad (22),$$

$$\mathrm{d}_0 e^{-r(t+1)} - d_0 e^{-rt} = \phi(d_0 e^{-rt} - d_0 e^{-r(t+1)} \quad (23)$$

$$d_0 e^{-r(t-1)}(e^{-2r} - e^{-r}) = \phi d_0 e^{-r(t-1)}(e^{-r} - 1) \quad (24)$$

$$e^{-r} = \phi \quad (25)$$

$$r = -\ln(\phi) \quad (26)$$

For the estimation of the convergence coefficient (ϕ) we use the Augmented Dickey Fuller (ADF)) regression in order to eliminate any potential autocorrelations:

$$\Delta\mathrm{d}_{i,t} = (\phi - 1)d_{i,t-1} - \sum_{j=1}^{k} \Delta d_{i,t-j} + \epsilon_{i,t} \quad (27)$$

By extending the methodological aspects put forward by Kočenda and Papell (1997) Albu, Iordan and Lupu (2012) from the macroeconomic area to the topic of financial markets we obtained the value of the ϕ parameter for the aggregate index calculed in the previous section. All the above mentioned computations have been conducted in Matlab.

4. Results and conclusions

Table 1 shows the results that characterize the level of convergence for the volatilities of the financial instruments.

Table 1: The results of the convergence coefficient

	φ	$r = -\ln(\varphi)$	**T-stat**	**Test 1%**	**Test 5%**	**Test 10%**
Volatilities	0.9362***	0.0659	-20.3395	-0.0247	-0.0180	-0.0140

Source: Authors' calculations

The results indicate a φ coeficient that is positive and above 1. This fact indicates the expansion of the convergence phenomenon for the Var coefficients calculated using the aggregation procedure mentioned previously.

By translating the methodological assumption used by Kočenda and Papell (1997) and Albu, Iordan and Lupu (2012) to the topic of financial assets, we conclude that for the analyzed period (January 2005 to November 2014) there are solid traces of a positive dynamics of the convergence of the volatility.

The significant level of the convergence coefficient is influenced by the evolution of the European financial markets during the economic crisis and by a similar evolution in terms of volatility for the following years.

This research can be extended to a study of the convergence indicator for sub periods (ante, during and post-crisis), in order to obtain a more complete and efficient estimation of the risk convergence process.

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