THE DEVELOPMENT AND THE CURRENT STATUS OF THE CAPITAL MARKET HYPOTHESES: A FEW BENCHMARKS

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Abstract
The capital markets are in continuous development and change, which raises the question whether the market hypotheses are still relevant and statistically valid in the present times. Thus, this paper presents an analysis of the development and the current status of the capital market hypotheses. Moreover, the paper presents a summary of the tests used to assess form efficiency in a developing market, and of the research methods used to detect chaos in a financial time series.

Keywords: market hypothesis, tests, chaos

JEL classification: C12, C58, C69

1. Introduction.

In 1965, Eugene Fama created the Efficient Market Hypothesis – EMH. He suggested that capital markets respond quickly to economic information, adjusting the prices of financial assets accordingly. A later alternative to it, by the name of Fractal Market Hypothesis – FMH (Peters, 1994), focuses on market stability instead of market efficiency.

More recently, the study of capital markets has involved the use of the chaos and fractal theories on emerging capital markets, with applications published in many works (Holyst, Zebrowska, Urbanowicz, 2001; Kantelhardt et all, 2002; Foroni, and Gardini, 2003; Timotej, Matej, 2004; Nualart, 2006;

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Oprean and Tănăsescu, 2013; etc). David A. Hsieh published a paper in the year 1991, in which he approached the following topics: "*What exactly is chaos and how is it related to nonlinear dynamics? How does one detect chaos? Is there chaos in financial markets? Are there other explanations of the movements of financial prices other than chaos?".* Following this, in 1996 Edgar E. Peters published the book entitled *"Chaos and Order in the Capital Markets: A New View of Cycles, Prices, and Market Volatility".* His book is the first to apply chaos theory to finance, and it was named "*the bible of market chaologists*" by The BusinessWeek. In their paper, Holyst, Zebrowska, and Urbanowicz (2001) presented how time-delayed feedback control can be used on a simple chaotic economic model.

Other important works: Kantelhardt et al (2002) used a generalization of the detrended fluctuation analysis in order to create a method for the multifractal characterization of nonstationary time series; Foroni and Gardini (2003) analysed the homoclinic bifurcations in heterogeneous market models; Timotej and Matej (2004) debated the chaos and order in capital markets in the case of a small transition economy; Nualart (2006) debated about the applications of the fractional Brownian motion; recently, Oprean and Tănăsescu (2013) showed some applications of chaos and fractal theory on emerging capital markets.

As mentioned before in this chapter, the fractal market hypothesis was created by Peters (1994) as an alternative to the efficient market hypothesis, and it focuses on market stability instead of market efficiency. The market is considered stable when it is "liquid", in the sense of an unbalanced transaction volume. If a market if liquid, then the market price is close to the "correct" one.

In contradiction to the efficient market hypothesis, the fractal market hypothesis considers that information does not have a uniform impact on the exchange rates, as information is assimilated differently, depending on the varying investment horizons, which assess information differently. At any moment in time, the exchange rates may not reflect the entire information available, but only the one important to the investment horizon.

The reason why chaos theory and fractal theory are used in finance is that the markets are nonlinear dynamic systems and because of that, using statistical models, such as the random walk model, to analyse standard data leads to erroneous results. A dynamic system is a collection of subsystems that interact with one another and, due to these interactions, evolve in time. A nonlinear system is a system with an inconstant change rate. The majority of the systems from the real world are nonlinear. Having an inconstant change rate means that the system changes at a variable rate, such as the currency exchange course.

One of the roles of chaos is to prevent synchronicity. Thus, it allows the components of a system to behave independently.

The rate of exponential divergence of two neighbour trajectories is measured by the Lyapunov exponent (λ). The Lyapunov exponent shows how much the trajectories diverge due to minor observation errors, minor shocks, or to other minor differences.

The error from the initial observation or the difference between two initial conditions is denoted by ε, and the distance from the reference trajectory is denoted by R. It is desired to find out how fast the second trajectory, which also includes error ε, will surpass R. The result depends on the number of iterations n and on the Lyapunov exponent λ:

$$R = \varepsilon \times e^{\lambda n}. \tag{1.1}$$

The Lyapunov exponent for a function $f(x(n))$ is the mean absolute value of the natural logarithm from its derivative:

$$\lambda = \sum \frac{1}{n} \left| \frac{df}{dx(n)} \right|_{n \to \infty}. \tag{1.2}$$

If the Lyapunov coefficient is negative, R becomes lower with each iteration, which means that, for a system to be chaotic, the Lyapunov coefficient must be positive. Generally, a system with M variables can have a maximum of M Lyapunov coefficients. In this case, an attractor is chaotic if at least one of its Lyapunov coefficients is positive.

A fractal is a geometric shape that can be separated into multiple parts, each of them being a smaller image of the original image. In finance, according to this concept, the evolution of the exchange rate of a title or a coin both look the same when the graphic is expanded or contracted. This property is called "self-affinity".

The process of generating a fractal starts with a straight line named trend line. Afterwards, three segments (from a broken line named generator) are used to create the graphic corresponding to the oscillating movement of the price. Each of the three segments that form the generator are then replaced by another three segments that represent the initial generator, but on a smaller scale, and so on.

In order to obtain a complete simulation of the price fluctuation, one may use multifractals. They are obtained by altering the generator, by expanding or contracting the horizontal time axis.

2. The efficiency of the capital market in Romania – a few benchmarks

In his thesis, Adrian Codîrlaşu (2000) used the random-walk theory, the Augmented Dickey-Fuller and Phillips-Perron tests, linear dependence tests, and fractal statistics, referring to all the forms of the capital market efficiency. One of his conclusions is that the studies developed by Romanian authors focus more on the correlations of the portfolio returns, by using returns calculated for long time intervals (1 year return, 2 years return etc.). He also reached the conclusion that, in a perfectly efficient market, the stock exchanges instantaneously adjust to the new information, and that the empirical tests for the semi-strong efficiency form are fewer than the ones for the weak form, because it is difficult to clearly identify the date in which a certain information becomes known.

In the year 2006, Bogdan Dima, Marilen Pirtea, and Aurora Murgea used the “Root MSE” test to obtain results for the indices of the financial market in Romania, for the time period 05.01.2004-16.11.2005 (daily data). The results suggested the fact that the efficient market hypothesis, even in its “weak” form, was not verified during the assessment period. In order to test the weak form, Dorina Lazăr, Andrada Filip, and Andrea Naghi (2009) demonstrated that one can also use regression tests.

In 2002, Alexandru Todea tested stationarity by using the Dikey-Fuller test. He analysed the profitability of 10 Romanian societies, however, he stated that the results cannot be extrapolated to the entire Romanian market. Moreover, in a paper published in 2008, A. Todea and A. Zoicas-Ienciu used random-walk tests to prove that the hypothesis of the Romanian market efficiency cannot be rejected. They also demonstrated that relatively long periods of random walk regarding the linear and non-linear dependencies between the Central and Eastern stock markets are interrupted by the effects of the linear or non-linear correlations.

For the analysis of the random walk of stock indices BET, BET-C, BET_FI BET, BET-C, BET_FI at the Bucharest Stock Exchange in year 2010, Vasile Brătian and Claudiu Ilie Opreana used stationarity testing, the Augmented Dickey-Fuller and Phillips-Perron tests, the Jarque-Bera test, and the random-walk test.

Unit root tests were used by Andrei Stănculescu and Eugen Mitrică (2012), who reached the conclusion that, depending on the risk behaviour of the investor, an investor that takes risks may appreciate an informationally ineficient market as a favorable ground for speculation, whereas an investor that does not take risks prefers an informationally efficient market that offers moderate returns, and in which there is a minimum portfolio risk.

Ion Stancu and Liviu Geambaşu (2012) assessed the weak efficiency form by using the Augmented Dickey-Fuller test, self-correlation tests, and partial correlation tests.

Victor Dragotă, Andrei-Alexandru Petculescu, and Laura Marinescu (2014), also tested the weak efficiency form by using unit root tests (Augmented Dickey Fuller and Phillips-Perron tests) and the Runs Test.

Alexandra Gabriela Ţiţan (2015) used random-walk tests to demonstrate that testing market efficiency is difficult due to the ever-changing nature of the market characteristics.

3. Chaos in financial time series

In a financial time series has been applied both deterministic and stochastic chaos. The concept of deterministic chaos has become of great interest recently. By definition, deterministic chaos represents the ocurrence of irregular chaotic motion in purely deterministic dynamical systems.

Lovejoy and Schetzer (1999) consider that nonlinear scale invariant dynamics imply stochastic chaos. In finance, Corcos et al. (2002) debate that an exponential growth cross over to a non-linear power-law growth rate. This will lead to a finite time singularity. Gaunersdorfer (2000) studied the adaptive rational equilibrium dynamics in a simple asset pricing model. The author also analysed bifurcation routes to chaos. Chen et al (2001) argued that market dynamics should be tested for the presence of chaos and non-linearity. Kyrtsou and Terraza (2002) tested for stochastic chaos in the evolution of price series.

The Lyapunov exponent used in the analysis of chaos in capital markets may be calculated with the software TISEAN C++ (Hegger et al, 1999), available online at the following link: http://www.mpipks-dresden.mpg.de/~tisean/. The chaotic behaviour of financial series implies both a random and imprecise character, namely the relativity of long-term forecasts, as well a fixed character, determined by time invariant objects, such as the system attractors. The Lyapunov exponent is the long-term temporal mean of the convergence or divergence of exponential speeds and of the neighbour states. If a system has at least one positive exponent, it is unstable and possibly chaotic. If the system has a deterministic behaviour, the attractor corresponds to the permanent basis towards which the system tends. The correlation dimension algorithm confirms the existence of the attractor and determines its dimension.

4. Conclusions

The investigations of the efficiency of the Romanian markets are focused on predictibility tests and case studies. Despite the progress shown by the statistical analysis, and the quantitative and qualitative improvements in stock market data and theoretical models, economists have not yet reached a consensus regarding the validity of the efficient market hypothesis.

The chaos theory and the fractal theory are new topics that have increasingly important applications in analysing capital markets.

5. References

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