THEORETICAL AND METHODOLOGICAL PROPOSALS REGARDING THE INFORMATIONAL EFFICIENCY OF FINANCIAL MARKETS

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Abstract:
The efficient market theory has given rise to numerous controversies which have further generated new research trends, some focusing on complex mathematical models, whereas others focusing on different hypotheses of financial markets approached form completely new perspectives.
In this article, we present the new paradigms in the field of financial market efficiency, such as: the Adaptive Market Hypothesis, the Noisy Market Hypothesis, the Fractal Market Hypothesis and the Behavioural Finance. Also, we analyse the effects of fractal market hypothesis and of behavioural finance on emerging capital markets.

Keywords: information efficiency, financial markets, fractal market, behavioural finance

JEL classification: G02, G14

1. Introduction: new paradigms in the field of financial market efficiency

The efficient market hypothesis (Fama, 1970, 1991) has begun to lose ground, and the rationality hypothesis failed to explain the excessive volatility of the returns and trading volume recorded on both developed capital markets and emerging ones (Oprean, Tanasescu, 2014a). It is therefore necessary to introduce new factors in addition to rational expectations to explain the evolution of returns and trading volume.

The drawback of any analysis of capital market efficiency is that it places too much emphasis on stock market indices, whose evolution seems to be highly sensitive to certain less quantifiable disturbances (e.g. political, social, psychological a.s.o. factors). Some of the new research trends approach financial markets from a biological perspective, more precisely an evolutionary one, based on the assumption that markets, instruments, institutions and investors evince a dynamic interaction and evolution, according to the "laws" of economic selection. Starting from this assumption, financial actors compete and adapt, however not relying on optimum behavior.

One of these research trends is the *Adaptive Market Hypothesis* (Lo, Andrew, 2004) as a recent version al EMH, emerging from evolutionary principles:

Species are distinct groups of market participants, each acting in a certain manner: fund managers, investors, market makers, etc. The adaptive market hypothesis has several implications that differentiate it from the efficient market hypothesis:

1. The relation between risk and return is unstable over time;
2. There are opportunities for arbitrage;
3. Investment strategies (including quantitative, fundamental and technical methods) perform well in certain environments and poorly in others;
4. The primary objective is survival; profit and utility maximization are secondary;
5. Innovation is the key to survival: since the risk-return relation varies, the best way of achieving an adequate level of expected returns is to adapt to the changing market conditions.

Another approach, the *Noisy Market Hypothesis* (Siegel, 2006), contrasts the EMH in that it claims that, in most cases, security prices are not the best estimate of the true value of a firm. It argues that prices can be influenced by speculators, as well as by insiders who often buy and sell shares for reasons unrelated to the fundamental value, but for diversification, liquidity, etc. These temporary shocks referred to as "noise" may obstruct the true value of securities and may result in inaccurate assessments of these securities for long periods of time.

Another line of research concerns the *Fractal Market Hypothesis*, proposed by Peters in 1994, who states that information does not have a uniform impact on prices. Every investor will assimilate it differently, depending on the investment horizon. Of paramount importance for the stock market are random fractals, which are combinations of shapes obtained by generating random rules on different dimensional scales. These combinations of random shapes derived from deterministically generated rules can provide configurations of fractals that may be used in analysing the stock market. To analyse stock data series, the chaotic, fractal model is used, closely dependent on the nonlinear paradigm (Oprean, Tanasescu, Bratian, 2014).

Another area of research in financial markets is *Behavioural Finance*, which investigates the subtle facets and interactions in the human brain, faced with the uncertainty of making economic decisions. The most common human traits (fear, anger, greed, selflessness) place considerable emphasis on our decisions about money. Intellect (grasping a situation), reason (long-term consequences of the action taken) and emotion (considering a course of action) are all interrelated; they are the springs behind human decision.

2. Behavioural finance – general remarks

Adding the behavioural finance perspective to the equation can help us to understand better how market agents will react. Human behaviour is generally reactive, not proactive; therefore, it is difficult to make predictions on the basis of narrow rules. Behavioural finances can relatively easily explain why an individual has made a decision, but have difficulty in quantifying what effects that decision will have on the individual.

Akerlof and Shiller (2009) substitute the rationality hypothesis to the investors' behaviour to explain the volatility of market profits. They attribute economic dysfunction especially to what they call "animal spirits" and extend the *General Theory* (1936) developed by Keynes. The latter defined animal spirit as "a spontaneous urge to action, rather than inaction". Although the author considered that most economic activities have rational economic motivations, people also have non-economic reasons, much of the economic activity being governed by these animal spirits. With this respect, the authors state that it is "necessary to incorporate animal spirits into macroeconomic theory in order to know how the economy really works." They extend Keynes's definition, the term "animal spirits" referring to the investors' irrational behaviour, as this comprises, among others, optimism, pessimism and spontaneous reaction. In modern economics, "animal spirits" have been coined into an economic term that refers to the restlessness and inconsistency existing in today's economy.

Another author (Dhaoui, 2011) has shown in his study that the economy is behaviour driven particularly by these animal spirits. He considered that excessive volatility results from the presence of optimistic, pessimistic and spontaneous investors. The assumption that investors carry out orders rationally does not explain how the economy works.

Information is a public set of data, made available to everyone in an objective manner. Information can have a material impact on the asset price when it is combined with knowledge, hands-on experience and assessment of investors. Investors interpret important data and events on two cognitive levels:

- the intellectual level of ordering, processing and analysing the actual factors (economic data);
- the level of the logical and rational understanding of how this objective identifies factors that will influence the perception of other market players.

The concept of information can be defined only by relevant data at some point on the market, but must be correlated with the amount of professional knowledge (human intellect) and interpersonal dynamics of market players (emotions and feelings). Moreover, due to uncertainty and constant change, there is a strong interdependence between experiences (autobiographical memory) and rational expectations about the future. Our experiences influence the way we view the available data based on relevance. If we add to these the decision equation (where the accuracy of the decision is recorded only *ex post*), time pressure, decision-related stress, we obtain the sum of the insecurities of the interactions between the rational and irrational.

Assessing market participants' psychological reasoning is very important − since other market players' decisions and actions have a decisive effect upon one's success or failure (*Game Theory*, J. Nash, 1950). In this case, building expectations is subject to time and constant insecurity pressure.

The human brain has a limited capacity to process, assimilate and comprehend the vast amount of information and stimuli that assail it every second. Our daily decisions and judgments (hundreds of them) suffer from constraints, personal circumstances, time pressure, psychological and emotional factors, being on the borderline between the rational and irrational. We often ignore a good decision merely because we are generally interested in the simpler, more reasonable and more feasible alternatives to our dilemmas. Our perception, especially when it comes to money, can be distorted and erroneous, influenced by our history, by current circumstances and future expectations. Our attitudes and decisions concerning financial matters are a cocktail of rational and irrational reasons. We reach a conclusion and implement a decision based on what we know now, being anchored in the information we consider to be relevant and losing sight of the wider perspective. Financial decisions are rarely optimal because of our simplistic, heuristic vision and emotionally-coloured reason.

3. The effects of behavioural finance on emerging capital markets.

To present the effects of behavioural finance on emerging capital markets, we refer in the following part to the analyses carried out in the article: "Effects of Behavioural Factors on Human Financial Decisions" (Oprean, 2014).

We studied the effects induced by temperament on investment behaviour, influencing trading volume evolution. Elements such as investor confidence leading to over-reaction (Barber, Odean, 2001; Daniel, Hirshleifer, Subrahmanyam, 2001), optimism (Scheier, Carver, 1985), pessimism (Barberis, Shleifer and Vishny, 1998, Kruger, Barrus, 2004) or, broadly speaking, animal spirits (Akerlof, Shiller, 2009), were taken into account to explain the link between investor behaviour and trading volume.

The purpose of the analysis was to investigate the factors that may explain the trading volume evolution on two emerging capital markets, Romania and Brazil. We analysed the impact of both investors who ground their trading behaviour on rational expectations and investors who show behavioural errors of the type described above as independent variables on the trading volume as dependent variable. The period under analysis covered nearly four years, from April 2009 to October 2012, and included the daily values of the most important indices traded on both markets, i.e. BET for Romania and IBOVESPA for Brazil, and the daily trading volume for each of the two indices.

Modelling the investors' behaviour, which is exposed to errors, was not an easy task, as no such model incorporating the investors' behavioural errors in a more comprehensive manner had been devised so far. Our approach to modelling these behaviour variables is presented below, so as to analyse them empirically, but a more comprehensive presentation of the methodology is given in the above mentioned article (Oprean, 2014).

In our view, a *confidence*-based investment behaviour will react as follows: if security returns on the previous day are positive (including zero), then overreaction implies that heavy transaction is expected on the current day; on the contrary, if security returns are negative, investors will either continue their trading strategy or refrain from trading. Thus, the relation between the independent variable and this dependent variable will be the effect of previous returns (positive or negative) on the trading volume.

Optimism occurs when on the preceding day investors reach a certain previously set level of profit, in this case actively reacting by increasing the volume of transactions. Optimistic investors will trade aggressively when the returns of the preceding period are equal to or greater than the value set by them, or else they will delay trading.

Pessimism occurs when investors incur loss the previous day. Thus, pessimistic investors will not trade when the loss in the previous period is greater than the value set by them; otherwise, if the loss is smaller than the limit, they will continue to trade.

In our study, we determined the value of the returns expected by a *reasonable investor* $E(R_t)$ by taking into account the profitability obtained on a previous date R_{t-1} and the residual factor specific to previous moment ε_{t-1}, in accordance with the following formula: $E(R_t) = R_{t-1} + \varepsilon_{t-1}$

After turning the initial series of returns into four data sets corresponding to each independent variable, according to the methodology described above, in order to test the influence of these factors on the dependent variable, trading volume, we calculated a linear regression.

Using regression, we could highlight the impact of the investors' rational expectations and behaviour errors on the trading volume for the two emerging capital markets considered.

The results indicate that, on a capital market, the investors' rational expectations fail to explain trading volume variability. Thus, the rationality hypothesis could be rejected for both capital markets. However, the results indicated that trading was influenced by the investors' irrational behaviour. On the Romanian capital market, pessimistic investors had the greatest influence on the trading volume, whereas on the Brazilian capital market, it was the optimistic investors who influenced the market activity in the largest measure. The results are not surprising. In fact, Romania's population is distrustful of the future, politics, media, etc. This implies that these investors have considerable aversion to risk. They react negatively after each crisis or loss, no matter how insignificant it may be. This may explain the negative effect of pessimistic investors on the trading volume for the stock market in Romania.

In the case of the stock market in Brazil, optimistic investors react positively following the profit made. They increase the volume of securities traded in anticipation of opportunities that may arise in the short term and that can be turned to the advantage of these investors. Their excessive reaction leads to a significant increase in the trading volume on the Brazilian stock market.

4. Chaos theory – general remarks

According to the classical theory, phenomena in the fields of economics and finance are characterized by a kind of mechanism subject to accurate measurement, prediction and control. On the other hand, chaos is a deterministic system defined by complex behavior relying on apparently random interaction among elements.

A shift from the analysis of intricate systems to complex systems is essential for a better understanding of economic phenomena (Munteanu, 2012). An intricate system may be modeled and controlled; it has a predetermined structure, a predictable dynamics enabling mathematical modeling by means of differential equation systems; and it may be investigated by a reductionist, causal, determinist and stochastic approach. Intricacy primarily includes: linear, superposition principle, Newtonian reductionism. On the other hand, a complex system co-develops alongside the environment; it is responsive to initial conditions, evinces self-organizing processes, it may shift from one operating system o another (stage transition); it is not subject to modeling by isolation and identification of purely causal relations, it is dependent on "history" and thus hard to investigate by a causal approach. Complexity includes: non-linear, progressive, contextual, holistic, transdisciplinary.

Chaos represents a status of non-linear dynamic system where apparently random events may be predicted by means of simple deterministic equations. Thus, chaos might be regarded as a new vantage point in the attempt of explaining economic phenomena, such as: fluctuations, instability, crises, economic depression.

Chaos theory has enabled the means of investigating complex systems due to the analysis of continuously moving systems. Despite that apparent state of disorder pertaining to the systems defined by this theory, chaos theory is in fact pursuing an internal order in all these seemingly random data.

Initially though, scientists believed that the chaotic movement of systems is neither predictable nor controllable given its sensitive dependency to initial circumstances. Small changes shall further trigger chaotic changes, and under no circumstances may lead to a stable and predictable alternative. Nevertheless, it is widely acknowledged by now that chaos may be capitalized and hence controlled, due to its deterministic structure, in spite of its unpredictability. Thus, a phenomenon seemingly unpredictable at local level, may become stable globally, have well defined boundaries and it may even evince sensitivity to initial conditions. Paradoxically though, this sensitivity of the chaotic system to initial conditions may be subsequently used to control it.

Chaos theory has been first mentioned in Henri Poincaré`s attempts of mathematical modeling of the instability of mechanical systems (in the 1880s). In 1898, the French mathematician, Jacques Hadamard, published a relevant study of the chaotic movement of a particle pointing out that the instability of all its trajectories is given by their exponential deviation from one another, with a positive Lyapunov exponent. Edward Lorenz, a meteorologist, was another scientist who experimented with chaos theory. In 1960, while he was working on a weather prediction problem, he noticed that even a slight change to the initial conditions is likely to change dramatically the long-term behavior of a system (this sensitive dependence on initial conditions is also known as the *butterfly effect*, a widely used concept in chaos theory). He introduced a homonymous concept – *Lorentz attractors* – where attractor refers to a set of points in the area of stages leading to the system trajectories, and the attracting pool defines a set of initial conditions leading where the trajectories converge to an attractor. Lorenz`s discovery highlighted that it is downright impossible to render an accurate long-term weather prediction, however it also enabled him to come across other issues later known as chaos theory; it mainly refers to the fact that complex systems seem to run through certain cycles of events (notwithstanding the difficulty of acknowledging a pattern in chaotic systems) although the events are rarely repetitive and identically rendered.

According to chaos theory and given the non-linearity and strange attractors, chaotic systems evince the following characteristics:

- they are deterministic, meaning that certain deterministic equations may be identified in view of governing their behavior;
- they are sensitive to initial conditions, since even the slightest change to initial conditions might lead to very different results;
- chaotic systems have no random or disorderly evolution.

Special attention has been given to the role of chaos in the field of finance especially due to the multitude of information and the interest in identifying predictable models (Oprean, Tanasescu, 2013). Tests have also shown that the market pricing of assets, though unpredictable, will evince a particular trend. The capital market is commonly acknowledged as a *self-similar* system, in the sense that its components are either similar or even identical to the whole. Another type of *self-similar* system used in mathematics is the fractal (the shape of the resulting structure is the same irrespective of the scale of representation). Hence, we consider it appropriate to compare the financial market to a fractal since a price graph analysis over a given time span will show their similar structure. Just like the fractal, however, the financial market evinces a sensitive dependence to initial conditions which makes the dynamic market systems hard to predict. It is our opinion that although a system may evince short-term unpredictability, it may however become a long-term deterministic system.

5. Fractal market hypothesis and measurement instruments

Recent studies, particularly after 1990, have focused mainly on developing new theory-based models, borrowed from other disciplines. Some of these models rely on the fractal theory indicating that the seemingly random evolution of the trend may be further decomposed in several similar evolution periods so that the initial series enables modeling (Peters, 1994, 1996).

Non-linear dynamic systems have also triggered an interest in fractals which have come to be regarded as the geometry of chaos perceived as a non-linear and deterministic dynamic system enabling the emergence of random, unpredictable results. The fractal concept was coined by the mathematician Benoit Mandelbrot (in 1975; 1982) in order to represent an object whose components provide an almost identical rendering of the whole: *plane or space figure, made up of an infinite number of elements, characterized by the fact that its statistical distribution and shape are not subject to change irrespective of the scale of representation.*

Here are some fractal characteristics:

- unending fragmentation (an infinity of components);
- self-similarity: the property of an object to render any item or similarity of the whole on any representation scale;
- translation invariant: the property of a fractal object to identify its item by means of superimposing it over another fractal area subsequent to translation on a given trajectory;
- fractional dimension, fractal dimension or self-similarity dimension.

There are two types of fractals: deterministic and random ones. Deterministic fractals are symmetrically generated whereas random fractals are not bound to evince any parts that identically render the whole. Throughout the time series in the stock exchange system we may identify fractals evincing, from a qualitative perspective, their own similarity on various representation scales. Random fractals have an outstanding significance for the stock exchange field – coastlines or cloud shapes are a relevant example, in this respect. Likewise the share price is similar to the coastline shape from the vantage point of high altitude, and the more we seek for a detailed perspective the more particularities we can find. Random fractals are a combination of shapes resulted from generating randomly selected rules on different scales of representation. These combinations of random shapes resulted from deterministic generated rules may lead to configurations of fractals applicable in the capital market analysis (Ghilic-Micu, 2002, p.264).

The theory and models regarding capital market operation have initially developed from the assumption that these represent efficient markets. Rational agents quickly assimilate any kind of information that proves relevant to asset pricing and their output and subsequently adjusts the price in accordance with this information. By way of explanation, agents do not benefit from different comparative advantages in the process of information acquisition. To sum up, the efficient market hypothesis refers mainly to three fundamental and highly controversial concepts, as we have mentioned in the previous chapters: efficient markets, random trajectories, rational agents.

Mandelbrot was the first one to notice the potential use of Brownian motion in the study of *motion* in other fields, such as: price motion on financial markets. The author introduces the concept of fractal motion as a generalization of Brownian motion (Zerfus, 1999). The new capital market theory combines fractals and other concepts from chaos theory with quantitative traditional methods in order to explain and predict market behavior. The fractal market theory (*Fractal Market Hypothesis – FMH)* (Peters, 1994, 1996) is a rendering of efficient markets where the focus is placed on market stability however, instead of market efficiency. Thus, it takes into account the everyday market randomness as well as market anomalies. This theory starts form the following assumptions:

- The market is stable whenever investors with different time spans operate. Hence, there is a large quantity of liquid asset that is an unbalanced transaction volume. A liquid market means that the price is close to its proper value.
- The multitude of information is much more connected to short-term market behavior and technical factors (information resulted from technical analysis) rather than long-term information (resulted from fundamental analysis). The larger time span the more significant long-term information becomes. Thus, changes in the pricing may reflect significant information only for the given time span.
- Should any element emerge that challenges the validity of a fundamental piece of information, then long-term investors are faced with two

alternatives: either they cease stock-market participation or they begin transaction relying on the multitude of short-term information (market attitude and technical data). As soon as all investment horizons become equally narrow, the market will get unstable. There are no long-term investors any longer able to turn the market into a stable one by providing liquidity to short-term investors.

- Prices reflect a combination of information related to (short-term) technical analysis as well as (long-term) fundamental analysis. Hence, short-term price changes tend to be either more volatile or noisier rather than long-term ones. The fundamental market trend renders the changes in expected revenue, based on the changes in the economic context. Short-term trends are the result of crowd behavior. There is no reason whatsoever to believe that short-term trend duration might be in any way connected with the fundamental economic trend.
- If an action is not related to the economic cycle, then there is no long-term trend. Liquidity, short-term information and transaction data shall prevail.

We may also compare the efficient market hypothesis (EMH) to the fractal market hypothesis (FMH) by highlighting their differences, as presented in the table below:

Table 1. Comparison of efficient market hypothesis and fractal market hypothesis

Efficient market hypothesis (EMH)	**Fractal market hypothesis (FMH)**
- Gaussian statistics - Stationary process - Economy has no memory (there are no historical correlations) - No repetitive models can be identified (regardless of the scale) - Continuous stability (at any scale)	- Non-Gaussian statistics - Non-stationary process - Economy has memory (there are historical correlations) - Several repetitive models can be identified at all scales (e.g. the Elliot waves[4]) - Potential instability in some scales (e.g. the *black swan* theory, Taleb, 2010)

6. The effects of fractal market hypothesis on emerging capital markets.

To present the effects of fractal market hypothesis on emerging capital markets, we refer in the following part to the analyses carried out in the article: “Fractality Evidence and Long-range Dependence on Capital Markets: a Hurst Exponent Evaluation” (Oprean, Tanasescu, 2014b).

Based on the *R/S fractal analysis method – rescaled range analysis* method - the methodology of computing is given in the above mentioned article – (Oprean, Tanasescu, 2014b), we made a classification of the 8 emerging financial markets, subject to analysis, on the basis of the Hurst exponent.

The data was represented by daily stock market quotes of the most traded indexes in the 8 secondary emerging capital market countries, four UE countries and the four BRIC countries (BET for Romania, OMX Tallin for Estonia, PX for the Czech Republic, BUX for Hungary, IBOVESPA for Brazil, SENSEX for India, RTSI for Russia, and the Shanghai Composite Index for China). The indexes were selected as they could best reflect and exhaustively capture all events on a market. Data series covered a period of over ten years since October 2002 until October 2012. The data sample consisted of an average of 2500 daily values of each index price separately.

Subsequent to the calculation of the Hurst exponent for the analysed stock-exchange indices, all rate series were antipersistent, since the value of the Hurst exponent ranges between 0 and 0.5. Therefore, the value of correlation coefficients was also less than zero, so that the series were negatively correlated. Hence, if a term in the sequence has increased, it will most probably decrease, at the next moment in time. All stock quote sequences underwent a fractal Brownian motion, different than the common random walk. The intensity of the antipersistent behavior is dependent on the *H*`s closeness to zero. If $H = 0$, then $C \ - 0.5$ and, under these circumstances, a sequence becomes highly volatile and subject to frequent changes. Since the system covers a smaller distance than in the case of random motion, its evolution changes its sign more often than a random system. Further to the classification performed in keeping with the Hurst exponent, we noted that the Chinese and Romanian financial markets were the closest ones to the random walk hypothesis, a characteristic of efficient market hypotheses. Nevertheless, the Brazilian and Russian financial markets were the furthest ones from the random walk premise, as they observed the fractal Brownian motion.

The *R/S* analysis shows the fractal distribution of short-term market performance distribution, which requires a self-similar structure. This hypothesis explains the structure by means of multiple investment horizons of investors. That is, the presence of investors who choose to invest on different time spans at any time scale will make the distribution probability time-scale independent, which can definitely be called a characteristic of a fractal distribution.

7. Conclusions

The efficient market theory might be considered an ideal model enabling the explanation / interpretation of market behavior, thus creating a new research direction regarding the efficient market theory. For instance, one can notice the relative efficiency of one market compared to others. Another perspective, though, is the expansion of efficient market definition to include the possibility of obtaining excess profit by investors who benefit from competitive advantage. The question is, of course, whether this situation should fall into the category of excess profit or bonus for competence and innovation. In the case of financial markets, such profits should not represent evidence of market inefficiency but rather a reward for new findings in finances.

We presented the new paradigms in the field of financial market efficiency, such as: the Adaptive Market Hypothesis, the Noisy Market Hypothesis, the Fractal Market Hypothesis and the Behavioural Finance. Also, we analysed the effects of fractal market hypothesis and of behavioural finance on emerging capital markets.

Following the obtained results, behavioural errors (optimism, pessimism, depression, anxiety, etc.) steadily won the dispute against reasonable behaviour. And when these different psychological make-ups occur in an overwhelming number of individuals, the effects are similar to those of tornadoes. For the intelligent investor, this is nothing but an opportunity. There is another important point to make with reference to the emotional factor: humans behave like animals, feeling safe in a crowd (crowd behaviour). If the others do the same, this confirms the wisdom of their decisions.

To conclude, the capital market represents a system with non-linear self-adjustment mechanisms that may be determined by a series of potentially random time functions, which explain the changes in the stock rates. In the context of a non-linear market model, the stock rate evolution may be determined not only by informational, systematic or arbitrary, but also by the non-linear dynamics of the market itself (intrinsic dynamics) (Ghilic-Micu, 2002). Likewise, a variety of other unpredictable sources may disturb the stock exchange system, hence any self-adjusting system becomes much more intricate than a mere logistics function.

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