

FINANCIAL MARKET MODELS. A LOGICAL ASSESSMENT

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Abstract: *The paper aims to analyze, from a logical and epistemological perspective - the possibility of knowledge, on the one hand, and the testability of knowledge, on the other hand - the main models developed and (some of them) operationalized in the financial transactions market. In this context, it is proposed to classify these models according to the „target” pursued and, based either on the statements of the creators of the models in question or (if such statements are missing or only implicit in theoretical developments), according to the fundamental principle (or the basic mechanism) specific to the models examined. The paper also examines the typology of the concepts of financial market efficiency, as it results from the logical and epistemological examination of the models in question. Finally, the paper analyzes the empirical testability (in the sense of Popper's falsifiability) for each of the financial market model considered (a number of six such models).*

Keywords: *financial market, efficiency, model, testability, principle, hypothesis.*

JEL Classification: *G10, G14, G29.*

1. Preamble

The concept of the model, as it has become „established” in the scientific community, is quasi-equivalent to that of theory – a set of theoretical/conceptual, methodological, and instrumental principles, regarding a field of knowledge (in natural sciences, in spiritual sciences or in the social sciences).

Conceptually, of the three possible categories of models (of discovery, of corroboration, of refutation), financial market researchers have constructed only corroboration/refutation models.¹ Although it is possible that in each researcher's personal laboratory, discovery models also worked – absolutely idiosyncratic – they were not made available to the scientific community or, if they were made, they do not prove to be anything other than corroboration/refutation models;

- (i) *formally*, of the four possible model categories (opaque/black-box, functional/evolutionary, behavioural/impact, decision/choice), two are the categories proposed and used in the financial market analysis: a) behavioural/impact models; b) functional/evolutionary models. Thus, the Efficient Market Hypothesis (**EMH**) model is a behavioural/impact model: any available past information is necessarily incorporated into the price (or other variable of interest in the financial market). The Behavioral Market Hypothesis (**BMH**)² model is also a model from this category. As for the Adaptive Market Hypothesis (**AMH**) model, it is a functional/evolutionary model. From a practical point of view (more precisely, praxiological one), analysts – either theorists or actual actors in the financial market – use many methods and techniques that, however, claim to be (or can be subsumed by) models or

¹It should be noted that the distinction between corroboration models and refutation ones is somewhat pedantic because a model that has the ability to corroborate hypotheses has it, *eo ipso*, and that of refutation. Popper's falsification implies either one result or another (but never implies an indecision – of course, only if we disregard with Duhem-Quine's thesis, according which we cannot, in principle, have an indubitable decision from the empirical testing of a hypothesis/conjecture).

²Which, in our opinion, is not completed in a „round” form (*Nota bene*: based mainly on perception, we believe that the phenomenological approach should be the methodological basis of this model).

theories as such.¹ The hypotheses proposed by this research are part of the category of models called functional/evolutionary;

- (ii) from the point of view of the *principles/axioms* on which the financial market models are built, we can say the followings:
- even if they are sometimes conceptually diametrically opposed approaches, financial market models are based, either explicitly or implicitly, on a single principle ;
 - a brief examination of the two categories of models currently developed leads us to identify (or formulate, if we are dealing with an implicit treatment) the fundamental principles of the main models of the financial market discussed in the specialty literature or operated on the financial market.

2. Brief logical examination of financial market models

2.1. Behavioral/impact models²

In the author's opinion, there are three financial market models that are of behavioral/impact type: (a) Efficient Market Hypothesis (EMH); (b) Fractal Market Hypothesis (FMH); (c) Cost Matters Hypothesis (CMH).

- (a) **EMH (Efficient Market Hypothesis)** : the fundamental principle is explicitly formulated by the initiator of the model (Fama *et al.*, 1969) : *the future price is independent of the past price, it is equal to the current price*. The basis of this principle lies in the very assumption of the information efficiency of the (financial) market – all past information (available and of interest/impact) is necessarily, immediately and without cost integrated in the price (or in the command variable in the financial transactions in question). All other behavioural/impact regularities of the model represent logical inferences from this principle (respecting, of course, the rules of valid inference);
- (b) **FMH (Fractal Market Hypothesis)**: the fundamental principle is explicitly formulated by the initiator of the model (Peters, 1994) : *the level of risk*,¹

¹All the „circulating” versions in financial theory and analysis can be subsumed under one of the two approaches. Thus, the so-called fractal approach to the financial market (*Nota bene*: some even call it Fractal Market Hypothesis – FMH, a name we also used here), introduced by Edgar E. Peters in 1994 (*Fractal Market Analysis: Applying Chaos Theory to Investment and Economics*) is an extension of EMH, trying, like the latter, to identify predictors in the „hope” that the kinematics of the financial market (more precisely of the records in the time series in question) behave fractal – it should be noted that we are in fact dealing here with a chaotic approach, in the sense of Chaos Theory, of the functioning of the financial market. It should be noted that the fractal approach is kept in the neoclassical „paradigm” of economic theory. Even the famous Black-Scholes model is based on martingale (fair game theory), that is. it works similarly to EMH. In essence, all these techniques, (to which is added Capital Asset Pricing Model – CAPM, as well as Modern Portfolio Theory) built under the „umbrella” of neoclassical economic theory claim the principle of equilibrium (imported from Newtonian mechanics) and presume the equivalence between investment and speculation, maintaining the analysis of the financial market in the game area (Peters, 1994) .

²Some authors (Lo , 2019) consider that the theory of rational expectations (the concept of rational expectation was introduced by Muth in 1961) is part of ... the paradigms of the financial market (theory). In our opinion, although EMH seems to verify the model criteria *qua* paradigm, we consider that the theory of rational expectations which, like EMH, is a necessary consequence of the neoclassical economic theory, based on equilibrium, has a lower span than that required by a paradigm. (*Nota bene*: however, the equilibrium theory is a paradigm!). As is well known, the theory of rational expectations (*Nota bene*: in our opinion it should be called as the theory of rational anticipations) has at least four deviations from its own assumption (Lo , 2019) : a) aversion to loss; b) overlapping on the probability – that is, on the behavior of the environment (see here the author's point of view, from the specialty literature, concerning the implicit information); c) the law of small numbers; d) heuristic representativeness (introduced by Kahneman).

scaled to different time horizons, is the same. One of the direct consequences is that the liquidity of the financial market is stable, that is, smooth and continuous, which makes the frequency distribution of the market return be the same for different time horizons. The foundation of this principle lies in what we can call (*Nota bene*: Peters did not provide such a wording) the liquidity efficiency of the financial market² – the large number and having different expecting horizons of investors ensure the smoothness and continuity of liquidity in the financial market.³ Although Peters strongly insists that FMH rejects the Gaussian distribution associated with time series, a closer look will reveal a crack in this insistence: the large number of investors (or players), as well as the large number of different expecting (that is, trading), horizons required for the operation of the fractal market hypothesis, implies, in principle (in the background), although indirectly, the hypothesis of perfect competition, that is, the Gaussian phenomenal distribution. However, FMH is much more empirically testable than EMH;⁴

- (c) **CMH (Costs Matters Hypothesis)**: this model was proposed by John Bogle (2003) which formulates, explicitly, his fundamental principle as follows:⁵ *investors as a whole will earn the gross return of the total stock market before costs but will only share the amount of that return that remains after costs*. The model emphasizes the important fact that success in the financial market depends not only on the return obtained (for example, the price) but also on ... the price of obtaining that return, that is, the cost involved in the transaction in question. In our opinion, this model is superfluous, only emphasizing one aspect of the cost-benefit analysis, which is, however, a common place in the investment decision. However, the CMH indicates a certain change in perspective of assessing the causality and conditionality of financial market behaviour:
- (i) *first of all*, it should be noted that, unlike EMH, CMH does not refer to the gross return (for example, the price) brought by a trading strategy operated on the financial market, but to the net return, that is, to the profit (difference between price and cost);

¹ The evoked author maintains standard deviation as a variable for measuring risk, although he also points out that this indicator varies faster than the square root of time (standard deviation is the square root of variance, which in fact is considered to „generate” volatility). It should be noted that, unlike the EHM model, the FMH one is empirically testable precisely by the way it formulates its guiding principle (*Nota bene*: from a logical point of view, for a financial market model to be scientific – that is, empirically testable, which is the same thing – the guiding principle, or alternatively a „theorem” inferred from this principle, must allow experimentation or experiencing, as the case may be, of the conjecture in question; this conjecture is, of course, in the form of a prediction (predictive statement).

²Such liquidity efficiency is fractal due to the self-similarity of the frequency distribution of the return of the financial market to different time horizons (expecting horizons) of investors.

³This phenomenon is, in turn, based on the essential feature of the fractal model of the financial market, namely that there is, at all times, a functional structural combination between microeconomic (local) randomness and macroeconomic (global) determinism. *Nota bene*: obviously, this idea is an application of the Prigoginian principle of the genesis of order (macroscopic aspect) from fluctuations (microscopic aspect).

⁴One of the most convenient conjectures that can be made here is to change the frequency distribution of the return, when the distribution of time horizons becomes uniform (that is, market liquidity decreases). This does not mean, *eo ipso*, that FMH is a paradigm – in fact, verifying that it is (or is not) a paradigm is a further research task.

⁵In original: *Investors in aggregate will earn the gross return of the total stock market before costs, but share only in the amount of that return that remains after costs*.

- (ii) *secondly*, this model is perfectly compatible with EMH (so, with the *homo oeconomicus* model generated by neoclassical economic theory), although the author insists on the idea that CMH must replace EMH. Consequently, the information efficiency of the market is accepted, but the validation (or selection) of a certain trading strategy is no longer external (that is, at the level of the financial market) – where, as a result of information efficiency, economic agents are indiscernible from the return (price) perspective but becomes internal, at the level of cost-benefit analysis of each economic agent;
- (iii) *thirdly*, the model is consistent (but only at a superficial level) with my own proposal (see APH below) because the *ex post* cost-benefit analysis of each trading strategy will lead to a change in the cost associated with that trading strategy, in the sense of reducing it;¹
- (iv) *fourthly*, based on the point immediately above, CMH interferes (but only at a superficial level) with Andrew Lo's proposal (see below AMH), because the change in cost associated with a trading strategy that can only bring an average return market will lead to a change in that strategy, that is, to a negative selection by the selector (*Nota bene*: as mentioned above, Lo considers the financial market itself as a selector, which introduces some logical inadvertences regarding the evolutionary aspect);
- (v) *fifthly*, the model is not continuously operational: for example, if there is no market information efficiency,² there is no need to change the cost associated with the trading strategy in question (unless an improvement in the net return of that strategy is desired, as independent of the functioning of the market);
- (vi) it can be said that CMH is a simple and credible explanation for the fact that EMH cannot function in a real financial market – thus, representing the second argument, in addition to the Grossman-Stiglitz paradox, against the EMH model (*Nota bene*: there is, however, a significant difference between the two arguments – while the Grossman-Stiglitz argument highlights the *inconsistency* , that is, the *self-contradictory* nature of EMH, the CMH argument highlights the *incompleteness* of EMH.³

2.2. Functional models of evolution

With regard to financial market models such as functional/evolutionary ones, I consider that they are the following: (d) Adaptive Market Hypothesis (**AMH**); (e) Adaptive Preference Hypothesis (**APH**); (f) Autopoietic Market Hypothesis (**APMH**).

- (d) **AMH (Adaptive Market Hypothesis)**: this model is (relatively) developed, especially, by Andrew Lo (2019), as a reaction , not too radical, to EMH , which he aspires to combine with behaviorism.⁴ The fundamental principle of

¹The superficial aspect of this consistency (or, rather, family resemblance, in Wittgenstein' syntagm) consists in the following: while, in the case of CMH, operates the practical rationality, in that of APH operates the theoretical rationality (*Nota bene*: any practical rationality implies a background of theoretical rationality).

²As is well known, the information efficiency of the market is „forbidden” by the Grossman-Stiglitz paradox.

³From another perspective, it can be said that the Grossman-Stiglitz argument examines the functioning of the EMH from inside, while the CMH argument examines the functioning of the EMH from outside.

⁴In this regard, Lo is ambiguous: sometimes he says that AMH makes a mix between EMH and behaviourism, other times he states that AMH is a generalization of EMH. In my opinion, EMH, on the one part, and any theory that leaves the canons of neoclassical economic theory (such as behaviourism), on the

this model (not explicitly formulated by the author, however) can be the following: *the price is dependent on the path (it has memory) and is established at the level of satisficing provided by the financial environment.* Some clarifying comments are needed here:

- (i) the concept of *satisficing* is the one created by Herbert Simon from the combination of the terms *satisfy* and *suffice* or to a sufficient extent;¹
 - (ii) *satisficing* no longer represents a price level neither at the level of the fair price nor at the level of the best price – the last one implying the optimization, i.e. maximizing the sale, respectively minimizing the purchase –, but represents the price that ensures, as a rule, the economic survival of the agent in question (trader);
 - (iii) it is quite obvious that the formulation of the fundamental principle of AMH, as done above, leads, *prima facie*, also to the idea of an efficient market – the state of the market in which no one can get more from the market than s/he needs for own survival. However, we guide the reader to notice a conceptual difference in market efficiency (or, equivalently, efficient market) between EMH and AMH: EMH refers to information efficiency, according to its own fundamental principle, while AMH refers to behavioural efficiency;²
- (e) **APH (Adaptive Preference Hypothesis)** : this model is the author's proposal on the functioning of the financial market, by „extracting” this functioning from the constraints of the *homo oeconomicus* model and placing it within an evolving market paradigm (Dinga *et al.*, 2022) .However, unlike the AMH model, I also propose a structural mechanism – the variation of adaptive preference (generated by *propensity* in the form of *proference*), under the impact of the selection of symbolic social fitness made by *cultural geodesic*. The fundamental principle of this model can be formulated as follows: *the distribution of the return of the financial market on trading strategies follows the distribution of the proference* (*Nota bene*: which obviously leads directly to the concept and process of co-evolution on the financial market – co-evolution is taking place between the return on a trading strategy and the propensity that generated the preference for that trading strategy). We present some clarifications regarding this model:
- (i) although it seems to be a commonplace that the economic agent chooses on the basis of his own preference (as it is modeled as a *proference* in the author's proposal), the *primary* qualification used in formulating the fundamental principle peremptorily shows that the cost-benefit analysis is secondary (or, if you will, complementary in logical and chronological order) to the preferential „analysis”;³

other part, are ... conceptually immiscible. However, behaviourism, in itself, is compatible with an evolutionary approach, as AMH is trying to do.

¹In the Romanian language we have the combination between (*satisfacere*), that is, *satisfying* and (*suficientă*) that is, *sufficiency*, so *satisficientă*, that is *satisficing*, reversing, however, the order from that of Simon's proposal, for reasons of both pronunciation and evidence of significance in Romanian.

²In fact, we believe that the very replacement of information efficiency with behavioral efficiency essentially expresses the basic pattern of this proposal.

³We can identify, here, a very interesting aspect regarding the economic choice, namely that this choice is one of the types of theoretical rationality, not of practical. Indeed, the theory of choice shows that theoretical rationality is based on belief (*Nota bene*: some authors consider that these are rational beliefs, based on justification or justifiability), while practical rationality is based on calculation) (Welton , 2012) .

- (ii) therefore, far from denying the rationality of choice or, more precisely, of making choices based on a model of rationality, APH emphasizes even more on this rationality, indicating, as its basis, the theoretical rationality, based on belief (or, in the terminology of this paper, on propensity that turns preference into proference), not the practical rationality, based on cost-benefit analysis;
 - (iii) obviously, the proposed model requires for a permanent inter-action between theoretical rationality and practical rationality, which is, in fact, the essence of the hypothesis itself;
 - (iv) this clarification is consistent with and underpins the construction of the behavioral efficiency of the financial market, as opposed to the information efficiency proposed by neoclassical economic theory; not even AMH focuses on this key issue of economic decision-making, but on the financial market's selection of the trading strategy ;
- (f) **APMH (Autopoietic Market Hypothesis)** : this model is the second proposal that the author makes in the context of this research. The fundamental principle of this model could be formulated as follows: *the distribution of the return of the financial market on the trading strategies follows the distribution of the replicability of the fitness of those strategies* . The following considerations develop, in a more analytical way, this fundamental principle:
- (i) APMH does not need either EMH or CMH to explain (justify) the distribution of return on active trading strategies in the financial market;
 - (ii) conceptually, APMH is part of the evolutionary model, like AMH but, unlike the latter, it goes beyond evolution (and even co-evolution), namely it aspires to shape the financial market as a self-evolutionary system or, using a term that appeared in biology but later expanded into almost all fields of science that claim to be evolutionary, an *autopoietic* system;
 - (iii) the autopoietic model of the financial market takes over self-organization, considered proper to biological systems and „imports” it into the economy (Foster, 1997); (Vromen , 2007), (*Nota bene*: two crucial hypotheses are also considered for the functioning of economic systems/processes: the continuity hypothesis, respectively the autonomy hypothesis. Of course, this approach requires what has been called a generalized theory of Darwinism – all these elements, together with the concept of entropy and in their interconnection, will be addressed in other communication;
 - (iv) the autopoiesis of the financial market requires two interconnected „circuits” (although with a certain mutual autonomy) of validation/adjustment – one at the level of the phenotype – environment relationship, another at the level of the internal environment – external environment relationship.

3. Short discussion

3.1. Regarding the type of efficiency of the financial market

All models of the financial market, discussed above, aim at or relate to the efficient financial market or, equivalently, the efficiency of the financial market – of course, each model comes with its own definition or acceptance of the attribute of efficient (or efficiency), as follows:

- (a) *EMH*: information efficiency

Information efficiency refers to that state of the financial market that no longer allows any gain above the market average (unless additional costs are incurred to ensure this gap above the market average, but which gap will ultimately do nothing else than to cover only that additional cost mentioned).

(b) *FMH*: scale efficiency

Scale efficiency refers to the invariance of the gain in relation to the scale (size, frequency, and other similar characteristics). In other words, whatever scale we choose for the financial transaction performed, the (unitary) gain returned by the market will be the same.

(c) *CMH*: structural efficiency

Structural efficiency refers to the fact that, although it is possible (as in the case of EMH) to earn above market average at the „price” of additional costs (for example, to take risks, or to find niches of opportunity), eventually the net gain will not be above the average net market gain.

(d) *AMH*: behavioural efficiency

Behavioural efficiency refers to the gain obtained (or obtainable, in potential situations) as a result of the memetic imitation of successful behaviours on the financial market, on the one hand, respectively of the inferring of implicit information from observing the behaviours of other financial market participants, so the implicit information then being used to adjust the observer's own financial behavior.

(e) *APH*: adaptive efficiency

Adaptive efficiency refers to the gain obtained (or, symmetrically, to the avoided loss) as a result of the adaptation of the trading strategy to the changes occurred in the market (opportunities, net profit margins, new economic actors, etc.). Although adaptation is a commonplace in any behaviour, the adaptive efficiency refers to the abandonment (or limitation) of strictly or exclusively rational models (*homo oeconomicus*) who have proven their inadequacy to real behaviors and favored behaviors based on empirical rules (*rules of thumb*).

(f) *APMH*: reproductive/replicative efficiency

Reproductive/replicative efficiency further carries the concept of adaptive efficiency, namely through the concept of autopoietic efficiency – autopoieticity ensures not only the preservation of efficiency but, to a certain extent, its improvement.

3.2. Regarding empirical testability

Regarding the testability (in the sense of factual falsification), we make the following statements:

Testability can be ensured both from the perspective of theoretical rationality (or rational belief or simple belief, equated in the present paper with the propensity that generates the preference), and from the perspective of practical rationality (equated in the present paper with the cost-benefit calculation).

Therefore, in order for testing to be possible, financial market models must provide at least a methodological anchor (either of the nature of theoretical rationality, or of the nature of practical rationality, or of both natures) that underpins the issuance/formulation of conjectures which will function as predictions or predictive statements.

From this perspective of testability, the six selected models regarding the functioning of the financial market are characterized by the followings:

- (a) *EMH*: this model is not testable – in its fundamental principle there is no reference to theoretical rationality or practical rationality. Besides, the specialty literature clearly notes this feature of the EMH model – its empirical non-testability (Berk, 2008) – the underlying explanation for this non-testability is, of course, the very substance of the hypothesis underlying

this model: a hypothesis not only unrealistic but, in many respects, erroneous;

- (b) **FMH**: this model is testable – based on its fundamental principle, conjectures can be issued which, then, through a careful organization of the experiment or observation,¹ can be either corroborated or rejected. It should be noted that the rationality on the basis of which it is possible to formulate predictive statements is of a practical nature (it does not refer to the beliefs, possibly rational, of the economic agents);
- (c) **CMH**: this model should logically be part of an extended EMH model that refers to the information efficiency of the financial market not from the perspective of price (that is, gross return), which has no significance for the economic agent, but from the perspective of net income/gain – that is, the difference between price and cost. In the absence of this „melt”, the model is a warning of the need for a more in-depth analysis than that allowed by the exclusive examination of price. From the point of view of testing, it can be considered that the model is non-testable, because the fundamental principle, although aimed at practical rationality (cost-benefit calculation, in other words) does not offer the possibility of formulating conjectures that can be observed and evaluated empirically;
- (d) **AMH**: this model is testable based on the arguments that any evolutionary model is testable. Its fundamental principle requires theoretical rationality, because *satisficing* is directly related to the (possibly rational) belief of the subject. Of course, from a technical point of view, the design, organization, conduct and observation of an experiment (either *in vitro* or *in vivo*) requires much more care for the correct capture of the co-evolutionary relationships that take place on the financial market . Although, in the vast majority of cases, the tests performed in the specialty literature are also performed from a perspective that we can call „objectual” (that is, one that focuses on facts, not behaviours), the model allows a test of behaviour, namely by capturing the aspects of choosing the second-best solutions;
- (e) **APH**: this model is currently in its infancy (Dinga *et al.*, 2022). However, its fundamental principle allows testing, from the perspective of theoretical rationality, because the adaptation of preference is done by changing the propensity (or, as I proposed, the preference as a dyad propensity – preference). Therefore, the formulation of conjectures (or predictions) should be made from the perspective of comparing the distribution of the preference, respectively the distribution of the return of the financial market;
- (f) **APMH**: this model, as such, is being developed and is part, in the present, of the scientific interest of the author of this paper. However, the approach of autopoieticity in economics is quite rich in the specialty literature, especially in the field of conceptual transfer from biology, with the founding contributions of Maturana and Varela (Maturana and Varela, 1980). Its fundamental principle is claimed both in theoretical rationality (originated in belief or propensity) and in practical rationality (cost-benefit analysis – also at the level of second-best solution, as in the case of AMH or APH). Therefore, there is a large possibility of formulating conjectures/predictions to test this model of the financial market.

¹*In vivo* observation/observation is also called as a *natural experiment*.

Some conclusions

The main conclusions that can be drawn from the previous analysis are the followings:

- (i) from the perspective of the degree of elaboration (both theoretical and methodological-instrumental) there are six basic models of the financial market (or financial theory), namely those examined in this study;
- (ii) each model of the financial market is based on its own type of market efficiency – financial market efficiency means, in all cases, the state of maximum market entropy from the perspective of that type of efficiency;
- (iii) in general, the development of financial market models has followed the path from the hypothetical-deductive type (i.e., EMH) to the co-evolutionary and autopoietic type (i.e., APMH);
- (iv) the methodology of improving the financial market theories/models is anchored in human psychology (both cognitive psychology and behavioral psychology);
- (v) as financial market models „move” from the hypothetical-deductive type (*homo oeconomicus*) to the co-evolutionary/autopoietic type, the degree of testability (empirical) of these models increases, which implicitly increases their scientificity (according to the separation criterion proposed by Karl Popper).

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