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FINANCIAL MARKET ANALYSIS AND BEHAVIOUR

THE ADAPTIVE PREFERENCE HYPOTHESIS

Emil Dinga, Camelia Oprean-Stan,
Cristina-Roxana Tănăsescu, Vasile Brătian,
and Gabriela-Mariana Ionescu

ROUTLEDGE

Financial Market Analysis and Behaviour

This book addresses the functioning of financial markets, in particular, the financial market model, and modelling. More specificall , the book provides a model of adaptive preference in the financial market rather than the model of the adaptive financial market, which is mostly based on Popper's objective propensity for the singular, that is, unrepeatable, event. As a result, the concept of proference, following Simon's theory of satisficing, is developed in a logical way with the goal of supplying a foundation for a robust theory of adaptive preference in financial market behaviour.

The book offers new insights into financial market logic and psychology: (1) advocating for the priority of behaviour over information – in opposition to traditional financial market theories; (2) constructing the processes of (co)evolution between adaptive preference and financial market, by using the concept of fetal reaction norms; (3) presenting a new typology of information in the financial market, aimed at proving point (1), as well as edifying an explicative mechanism of the evolutionary nature and behaviour of the (real) financial market; (4) presenting sufficient and necessary, principles or assumptions for developing a theory of adaptive preference in the financial market; and (5) proposing a new interpretation of the pair genotype-phenotype in the financial market model.

The book's distinguishing feature is its research method, which is mainly logically rather than historically or empirically based. As a result, the book is targeted at generating debate about the best and most scientifically beneficial method of approaching, analysing, and modelling financial markets.

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Preface

The (natural) ambition for economic theory to be comparable to physics (considered as the 'cornerstone of scientificity') has historically resulted in a serious epistemological error, which is still felt: the uncritical import, *tale quale*, of natural sciences, models, methodology, and even technical instruments (see differential equations). This period of epistemological wandering is about to end: behaviourism (with the exception of pan-psychological excesses), cognitive sciences (including neuroscience), biology, still proposed by Marshall as a paradigm of economics (even medicine), institutionalism, and, at the most aggregate level, evolutionism have been working together for decades to achieve a realistic paradigm of the economic world and economic behaviour. From Friedmanian-type fundamentalist positivism to mixed evolutionism (genetic, memetic, and semetic), that is, from an instrumentalist to a social theory, from economics to political economy, economic theory advances rapidly and decisively.

This book aims to provide such an evolutionary approach to the scientific debate in a specialized field – that of the financial market. And, for more than a half-century, this field has been dominated by *homo œconomicus* models (such as, e.g., the Efficien Market Hypothesis), which are necessary logical manifestations of neoclassical economic theory. The critical, respectful, and constructive examination of recent scientific advances in financial theory in the institutionalist-evolutionary direction serves as the foundation for many original (but, of course, controversial) proposals that we make, both conceptually and methodologically, in order to contribute to the development of a model (theory) of the financial market that satisfies both the requirements of coherence and consistency and those of (factual, in Popper's sense) testability, that is, of scientificit . In essence, this book lays the groundwork for a possible Adaptive Preference Hypothesis in the financial market.

More specificall , the book provides a model of adaptive preference in the financial market (rather than a model of the adaptive financial market), which is mostly based on Popper's objective propensity for the singular (i.e., unrepeatable) event. As a result, the concept of proference (following Simon's theory of satisfi - ing) is developed in a logical way with the goal of supplying some bricks for a robust theory of adaptive preference in financial market behaviou .

Some new insights into financial market logic (and psychology) support the book's purpose in front of the scientific community: (1) advocating for the priority of behaviour over information (in the opposite direction of traditional financial market theories); (2) constructing the processes of (co)evolution of adaptive preference – financial market by using the concept of fetal reaction norms; (3) proposing a new typology of information in the financial market, aimed at proving point (1), as well as edifying an explicative mechanism of the evolutionary nature and behaviour of the (real) financial market; (4) presenting sufficien (and necessary) principles (assumptions) for developing a theory of adaptive preference in the financial market; and (5) proposing a new interpretation of the pair genotype-phenotype in the financial market model (e.g., different from Adaptive Market Hypothesis's (AMH) option).

The content of this book is linked to neoclassical initial products in financial market modelling, (old and new) techniques supplied by behaviourism (including neurosciences), and more recent theoretical formulations from an evolutionary/institutional perspective.

The book's distinguishing feature, in our opinion, is its research method, which is mostly logical (quite close to deductive) rather than historically or empirically based. As a result, the book is essentially a challenge to the scientific community in the field of financial market concerns, encouraging the development of a new paradigm in this subject based on the concept of adaptive preference.

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1 Adaptive preference

Introduction

Rationality, expectation, belief, preference

Rationality is defined as a property (either of a decision or of an action) in relation to a given model of rationality. Therefore, there is no absolute rationality, or itself, but only a contextualized (or relative) rationality for a given model of rationality. Models of rationality can be either explicit, often formalized (as in the model of economic rationality within neoclassical economic theory, known as *homo œconomicus*), or implicit (which is the case of behaviourist models or, more recently, evolutionary models, inspired by the biological paradigm). If we note with $\mathcal{M}_{\mathcal{R}}^{i}$ a model of rationality i, then a decision j taken into context of the given model of rationality $d^{j}_{\mathcal{M}_{\mathcal{R}}^{i}}$ can be of three categories (all related to $\mathcal{M}_{\mathcal{R}}^{i}$):

- *rational* decision – when it is validly inferred[1] from $\mathcal{M}_{\mathcal{R}}^{i}$, noted with $d^{j}_{\mathcal{M}_{\mathcal{R}}^{i}}$;
- *irrational* decision – when it is invalidly inferred from $\mathcal{M}_{\mathcal{R}}^{i}$, noted with $\overline{d}^{j}_{\mathcal{M}_{\mathcal{R}}^{i}}$;
- *a-rational* decision (or logically inferred) – when it has no relationship with type inference $\mathcal{M}_{\mathcal{R}}^{i}$, noted with $\tilde{d}^{j}_{\mathcal{M}_{\mathcal{R}}^{i}}$.

Of course, what appears as *irrational* or *a-rational* in relation to one model of rationality can be *rational* in relation to another model of rationality and vice versa. Thus, if we note a decision k, $d^{k}_{\mathcal{M}_{\mathcal{R}}^{q}}$ in relation to a model of rationality q, $\mathcal{M}_{\mathcal{R}}^{q}$, we can have any of the following situation: the noted logical constant $\bowtie$ has the meaning 'is compatible with' ($\overline{\bowtie}$ means 'is incompatible with'), and the logical constant $\rightarrow$ has the meaning 'validly implies' ($\nrightarrow$ means 'does not validly imply'):

- formalization of the *rational* decision:

$$d^{j}_{\mathcal{M}_{\mathcal{R}}^{i}} \Leftarrow \left[\left(d^{j} \bowtie \mathcal{M}_{\mathcal{R}}^{i}\right) \wedge \left(\mathcal{M}_{\mathcal{R}}^{i} \rightarrow d^{j}\right)\right]$$

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- formalization of the *irrational* decision:

$$\overline{d}^{\,j}_{\mathcal{M}^i_{\mathcal{R}}} \Leftarrow \left[\left(d^j \bowtie \mathcal{M}^i_{\mathcal{R}}\right) \wedge \left(\mathcal{M}^i_{\mathcal{R}} \nrightarrow d^j\right)\right]$$

- formalization of the *a-rational* decision:

$$\tilde{d}^{\,j}_{\mathcal{M}^i_{\mathcal{R}}} \Leftarrow \left[\left(d^j \bar{\bowtie} \mathcal{M}^i_{\mathcal{R}}\right) \wedge \left(\mathcal{M}^i_{\mathcal{R}} \rightarrow d^j\right)\right] \vee \left[\left(d^j \bar{\bowtie} \mathcal{M}^i_{\mathcal{R}}\right) \wedge \left(\mathcal{M}^i_{\mathcal{R}} \nrightarrow d^j\right)\right]$$

Human behaviour may take place under four 'authorities': under the authority of rationality, under the authority of expectation (subjective), under the authority of belief, and under the authority of preference.

Of course, this typology is rather academic because, in fact, the four 'authorities' can be combined two by two or (which is, additionally, the most common case) co-exist in different weights, weights which, in turn, change because of the experience, as a result of environmental pressure, or as a result of both causes.

Behaviour led by rationality

It is a behaviour based exclusively on inferring the decision from the pre-accepted model of rationality (in the logically way described earlier). It is the behaviour considered in neoclassical economic theory[2] (under the empire of which the efficien market hypothesis (EMH) was also constructed), which considers the human individual as having a hyper-rationality in choosing the optimal decision (i.e., the decision which extremizes an objective function under given restrictive conditions or, equivalently, minimizes the opportunity cost under those conditions). The best-known logical model of this type of behaviour is the (mathematical) *homo œconomicus* model. Over time, this abstract model has been relaxed in many ways (including here Simon's concept of bounded rationality, as well as other formal relaxations), but rational behaviour remains predominant.

Behaviour led by expectation

Behaviour led by expectation is based primarily on behaviourist studies[3] (behavioural economics), and the economic decision is based on a combination of rationality and emotion (fear and various aversions to risk, to loss, etc.), considering even that 'realistic' rationality contains emotion.[4] Behaviourism accepts the important role of the individual's past (experience) as an economic actor. In essence, an expectation is subjective (and, therefore, strongly idiosyncratic) and is manifested by the allocation of Bayesian probabilities[5] events (occurring under conditions of uncertainty, which are logically equivalent to the absence of any information that would associate risks with the events concerned and which, by this allocation, would change the probabilities associated with them). The phrase 'rational expectations', extremely common in the literature, is quite ambiguous because being subjective, the expectation cannot be rational – because if it were

rational, it would be associated with a model of rationality, so it would not be subjective (namely, free, based on free will or, at least, idiosyncratic desirability). Probably, those who use this phrase intend to say 'rational anticipations', which is something else entirely.[6]

Behaviour led by belief

Regarding behaviour led by belief, this is intended to be a more comprehensive theory related to that of behaviour led by expectations, in the sense that it is considered (in an axiomatically way) that the individual is 'endowed' with a (complete) system of beliefs about economic phenomenology, beliefs which underlie its decisions and actions (including, of course, religious beliefs, ethical values, etc.). This theory is closely linked to the theory of justification and, as a result, is more a post-factum theory than one which would constitute an operational predictor on the economic market (or, more specificall , on the financial market). Belief (put into relation with motivation, intention, and other psychological 'objects') constitutes one of the arguments of behaviourism (and evolutionism) for shaping the economic decision. In the specialty literature, the following categories of beliefs are considered:

- *overconfidence* in their own judgements (i.e., self-attribution – luck is attributed to their own talent; *hindsight* – ex post, individuals always find that they 'predicted' well);
- *optimism*, desire-oriented thinking, and greed;
- *representativeness*, which leads to an underestimation of the sample size (there are two failures of representativeness, especially in assigning probabilities: (1) neglect of the base rate; (2) neglecting the sample size);
- *conservatism*: leads to overestimation of the sample size;
- *perseverance* of belief: inertia in renouncing the formed belief;
- *anchoring*: availability errors – information that is no longer available in memory (Barberis & Thaler, 2012).

Behaviour led by preference

Behaviour led by preference is, in a way, a wrapper of all three types of behaviours described earlier, in the sense that the individual (actor or economic agent) externalizes both his model of rationality and idiosyncratic expectations and beliefs, through the preference. So, in a way, the preference is a synthesis (not aggregation, because the three bases of behaviour are, in principle, incommensurable two by two) of the whole 'economic personality' of the individual concerned. Although the authors did not agree on a 'list' of preferences (which, as mentioned earlier, are sometimes considered beliefs), in principle, there are three such preferences: (a) risk aversion; (b) aversion to loss – see Prospect Theory (Kahneman, 2012); and (c) aversion to ambiguity. In what follows, we will focus only on this type of economic behaviour.

The concept of economic preference

In economic theory, economic preferences mean anchors of behaviour of the individual (actor/economic agent) which are, in the most general sense, predictors of the behaviour concerned. There are two basic characteristics of economic preferences: (a) they are considered given, namely, they represent variables (in fact, rather, constraints) exogenous for the economic analyst;[7] and (b) they are idiosyncratic, namely, specific to each specific individual (or, as the case may be, to each representative agent, if modelling based on representative agents is used), which means that they are incommensurable between any two individuals. More precisely, economic preferences act on economic behaviour analogously with the action of the principles assumed (and publicly announced) by each individual or, where appropriate, by each class of individuals considered homogeneous within that class and from the perspective of the accepted classification criterion.[8] In this context, we can define economic preference, at the individual level, as the *maximum probability of choice in conditions of uncertainty*. The justifications for this content of economic preference are as follows:

- in connection with a choice (or equivalent, with a decision between at least two measurable alternatives[9] between them), there may be two situations: (a) each alternative can be associated with both a utility[10] and a risk, based on which the so-called rational expectation can be calculated (e.g., in the axiomatic logic model called *homo œconomicus*), following that the choice to be the alternative is one with the highest rational expectation; (b) no substantive utility or specific risk can be associated with the alternatives, that is, we are in a situation of uncertainty.[11] In situations of uncertainty, there is no information on future events, so no rational calculation can be made[12] – a case in which equal probabilities are assigned to events, based on the principle of insufficien reason (introduced by Laplace in his work on probability theory);[13]
- therefore, based on the subjective probability and in conditions of uncertainty, we can expect a rational individual to allocate equal probabilities of occurrence to each alternative event (of course, provided that the sum of the probabilities is 1 and no probability is negative,[14] if the events in the field of events considered are exclusive and exhaustive). If, however, that individual allocates unequal probabilities to each other, then the highest of these probability values must be considered as expressing an option 'dictated' by his economic preferences. We mention that we are talking here about subjective probabilities, not about frequential probabilities. This means that, on the one hand, those probabilities can also be attributed to singular (unrepeatable) events,[15] and, on the other hand, being subjective, they can take over the idiosyncrasy (which is externalized by the manifestation of economic preference)[16] specific to each individual/decision-make .

Thus, the economic preference, whether or not it is conscious (awareness of preference means putting it in a model of rationality that 'delivers' a rational decision), acts as a disruptor on the principle of insufficien reason, allocating to an event in the field of events given a probability that is higher (or lower)[17] than the others, with equal values between them. In a sense, economic preference acts as a 'probability attractor', but we would prefer to be considered, rather, as a geodesic (analogous to cosmological geodesic) having the capacity to 'curve' the economic decision towards it. Of course, the consideration of economic preference as a geodesic on which the decision of the economic individual moves is, for the time being, a descriptive metaphor, but it can be (and the study will provide such a development) formalized.[18]

The role of economic preference in economic behaviour

In essence, economic preference plays the role (expressed in an abstract way) of violating the principle of insufficien reason when the decision is taken under conditions of uncertainty. Of course, even if the uncertainty is not complete – for example, events in the field of exclusive and exhaustive events may be associated with risks, which change the level of probabilities from their equal value – the 'disruptive' role of economic preference is preserved. This is the deep reason why it has been said earlier that knowledge of an individual's set of economic preferences works as a predictor of that individual's behaviour. The role and functionality of economic preference can be synthesized synoptically (Figure 1.1).

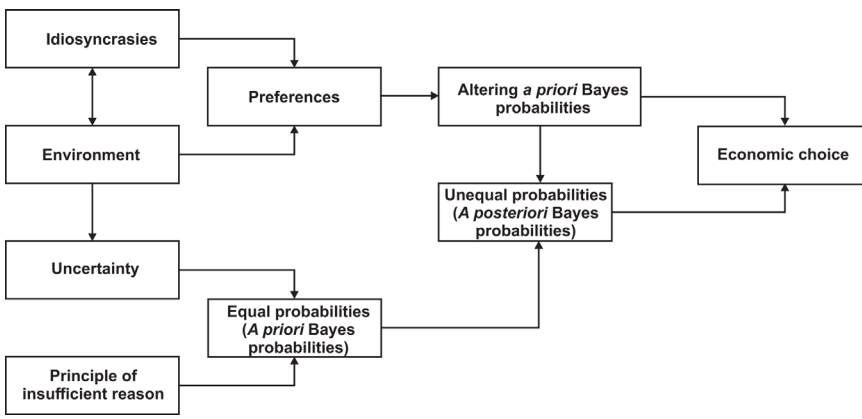

Figure 1.1 The role of economic preference in economic choice.

Source: Authors.

The concept of adaptation

The phrase *adaptive preference* has two semantic components: the substantival component – *preference* – and the predicative component – *adaptive*. As the substantival component has already been discussed in section "The concept of economic preference", the predicative component remains to be examined.

The term *adaptation* comes from the Latin *adaptation*, being taken, this root, also in English *to adapt, adaptation*. In general, in fact, any preference is adaptive, because it cannot function in an environment with which it is functionally incompatible. Individuals who had contradictory preferences with their environment have vanished – unless these preferences were adapted to the environment in question.[19] However, the adaptive predicate associated with preference (especially economic preference) requires more analytical comments.

Firstly, the content of the adaptation process must be explained. For there to be a process of adaptation, there must be at least two ontological entities, linked either structurally or functionally. It is not enough for this connection to be structural (based on the fact, accepted by systems theory, that function follows the structure) because we can have functional relations without having structural relations. Therefore, if we make a temporal 'cut', at some point there must be an entity that adapts and an entity to which the previous entity adapts: the first entity is called *adaptant*, and the second entity is called *adaptar*.[20] The specific relationship between the adaptant (denoted by a) and the adaptar (denoted by A) is called the adaptation relationship or function (denoted by $\mathcal{A}$). As the adaptation relation, as well as the roles of the two entities, depends on the temporal 'cut' operated, it results that we need the time variable to 'date' the respective relation, namely:

$$\mathcal{A}_t^{(0)} = \mathcal{A}\left(a_t^{(0)}, A_{t-1}^{(0)}\right)$$

Therefore, at time (t), the adaptant adapts to what the adaptar was at the immediately preceding time $(t-1)$.

Secondly, the dynamic nature of the adjustment relationship must be taken into account, which can be formalized as follows:

$$A_t^{(1)} = f\left(\mathcal{A}_t^{(0)}\right)$$

$$\mathcal{A}_{t+1}^{(1)} = \mathcal{A}\left(a_{t+1}^{(1)}, A_t^{(1)}\right) = \mathcal{A}\left\{a_{t+1}^{(1)}, f\left[\mathcal{A}\left(a_t^{(0)}, A_{t-1}^{(0)}\right)\right]\right\}$$

That is to say that, at some point, the adaptation process preserves the adaptation function, changing only the exogenous variables (of course, what we have called as the adaptation function, that is $\mathcal{A}$, must be formally explained – we will 'ask' at the right time that the formal expression to be analytical, not simply numerical, in order to give it as much explanatory force as possible).[21] Also, the function f must be explained formally (also analytically). These formal developments will be presented subsequently.

Thirdly, the fact that must be remembered is that the adaptar alternately (either at every moment of time or at certain intervals)[22] becomes adaptant, and vice versa, the adaptant becomes adaptar. Thus, changing the roles of cause and effect entails establishing norms of act – reaction between the adaptant and the adaptar in order for the ecological system (as proponents of evolutionary theory refer to the fina - cial market considered under this paradigm) to be viable – that is, to survive.

The concept of adaptive preference

By *adaptive preference* we mean the preference (of economic type, in present study) that appears, changes, and manifests (it works) in an adaptation process, as conceptually described in section "The role of economic preference in economic behaviour". We will call the system consisting of a and A *ecological system* E.

According to the terminology used in the field of biological systems, $E = \{a, A\}$. As it is known, the economic preferences taken into account in the logical model provided by neoclassical economic theory (i.e., in the *homo œconomicus* model), are considered invariant, that is, given, from the beginning in the 'endowment' of the economic individual who makes decisions and carries out activities (*Nota bene*: activities are of two types: (a) actions – to do; (b) abstentions or inactions – not to do) and which remain unchanged, both as a 'list' and as a hierarchical order within them.[23]

Because the entire study is devoted to 'deciphering' the concept of adaptive preference, we will only make a few preliminary observations here, completely general, and the main part of the presentation will be developed in the following paragraphs.

- adaptive preference *is not invariant* (neither as a list of preferences nor as a ranking of them within the lists); it is influenced by the impact of its application on the economic decision and the activity associated with that decision;
- the variability of the preference is generated by the *process of adaptation* within the ecological system; the impact between a and A is bidirectional, having a certain symmetry, even if not a perfect one (as intensity, or as frequency);
- although preferences remain idiosyncratic, *classes of economic actors* who share the same set of preferences can be identified (possibly with the same lexicographical order between them): insurance funds, risk funds, mutual funds, and so on;[24]
- adaptive preference replaces the *first-best* solution (optimal) with a *second-best* one (suboptimal);
- adaptive preference does not seek to maximize the outcome (decision or activity) but rather *survival* in that ecological system.

Regarding the concept of economic (adaptive) preference, four additional clarifications may be useful for the further analyses:

1 although it is not entirely incorrect to equate preference with belief, at least operationally, that is, in empirical analyses, it must be stated that preference

is a species of belief that must be considered genus. In other words, a certain belief – for example, the belief that the trading game is fair (the rules of the game are set without bias) and that all players are, in turn, fair, playing their chances honestly – can generate one or even more preferences. As a result, preferences must be based on belief. It is, of course, also possible for a certain preference to be claimed from an accumulation (contest) of faiths, but the preference will always be a species, and the belief will always be a genus;

2 preference (or belief, not to be confused with the aforementioned precautions) should not be confused with trading game heuristics. For example, the emotion with which a certain decision is made is related to heuristics rather than preference. In other words, the objectification of items is always in the form of heuristics (as evidenced not only in cognitive psychology and behavioural psychology but also in adaptive market hypothesis (AMH), which desired a synergistic combination between EMH and behavioural economics and behavioural finance) (Lo, 2004). In fact, the preference, not being transparent, is, as a rule, inferred logically precisely from the heuristic found (observed, recorded) in artificial or (rarely) natural experiments;[25]

3 preference should not be confused with rationality. The problem is relatively difficult, at least for the following reasons

- the survival instinct – inculcated in the human individual by his (extremely long, compared to how long the individual is protected by society and technology) belonging in the natural world – has, of course, been influenced by his models of rationality: for example, the individual has learned that, for survival, it is important not to make type 1 mistakes, while making a type 2 mistake had no consequences for the choice between life and death;[26]
- to avoid type 1 errors, it is necessary to develop a rationality model while also developing a preference that guides decision-making (e.g. the decision to run away from what appears to be a predator, although the probability of not being a predator is high – as in the case of a savannah where herbivores predominate). The separation between the model of rationality and preference is made from the perspective of awareness/unconsciousness: thus, if the decision is made consciously, we are dealing with a model of rationality, and if the decision is influenced by the subconscious, we are dealing with a preference;[27]
- one can presume an interdependence or even a reciprocal transition between the model of rationality and preference,[28] with the following characteristics: (a) any preference comes from a model of rationality as that model has entered behavioural automatisms (which is why we stated earlier that the phrase ‘adaptive preference’ is, in essence, a tautology because the adaptive predicate is already included in the topic of preference – we have here exactly the definition of Kant’s analytical sentence,

a sentence that is also called tautology); (b) the reversal of preference in the model of rationality is done precisely through the process of adaptation (we note that this logical mechanism will be one of the critical comments – and original contribution of this study – that will be made to Lo's AMH theory).

4 the hierarchy of preferences is one of the most difficul problems in decision theory (science) and, therefore, in economic behaviour. This issue will be thoroughly addressed in this study, but it is necessary to state right now that this hierarchy has two fundamental characteristics: (a) it is established lexicographically[29] and (b) it is strongly idiosyncratic and therefore incommensurable inter-personally or intra-personally and inter-temporally.[30]

State of the art

Regarding the acceptance of the concept of adaptive preference, in the literature, the general characteristics can be summarized as follows:

- a lack of broad agreement on the definition and operationalization of the adaptive preference concept;
- the existence of at least two major perspectives under which the adaptive preference concept is used (a) in a narrow sense, that is, from a purely economic perspective (especially microeconomic and, even more specificall , with regard in particular to consumer or investor behaviour); and (b) in a broad sense, that is, from the perspective of social justice;
- the concept of adaptive preference is used as a qualitative concept that lacks quite enough valence to be measured (or, as is often wrongly said, to be quantifie [31]). In most cases, adaptive preference is considered as an adaptation reaction to the environment (as the name implies) and not as an endogenous preference;[32]
- most approaches to adaptive preference give this concept a negative connotation, regardless of denotation accepted, and that is that 'guilt' for objectifying adaptive preference is thrown on the individual (microeconomic decision-maker – that is, following a mistaken assessment of the environment), or on the society (the societal environment);
- adaptive preference leads to the replacement of the first best solution (specific to the complete rationality model of *homo œconomicus*) with the second-best solution (specific to the evolutionary or biological model), regardless of whether the analysis is carried out under the aegis of equilibrium or survival (i.e., in fact, a criterion of balance on a long-term basis or using a relatively recent term entered in the scientific vocabulary, and also in the public one, especially political, under the aegis of sustainability).

The meaning given to the concept of adaptive preference is not homogeneous in the specialty literature. The main approaches of this concept can be put under the

'authority' of four types of approaches: (a) from the perspective of neoclassical theory, (b) from the perspective of behaviourism, (c) from the perspective of institutionalism, and (d) from the perspective of evolutionism.[33] We will make brief considerations on each type of approach.

The neoclassical perspective

In the neoclassical perspective, there is no solid concept of adaptive preference because (economic) preferences are considered to be given in the 'dowry' of the individual, that is, they are considered exclusively endogenous and, in addition, invariant. Even if, in some more realistic models, the hypothesis of variability of preferences is accepted, this variability is seen in a static way – a new list of preferences is simply introduced (or, if the model is more sophisticated, a new hierarchy of preferences) but also the new list (or the new hierarchy) is considered, again, given and invariant. In other words, in the neoclassical perspective (which gave, let us recall, the logical model of *homo œconomicus*), preferences are not of the adaptive type because a mechanism for adapting preferences is not provided. This perspective was, moreover, the basis of EMH (Lo, 2004), which confined EMH to an area as artificial and unrealistic as any scientific construct based on the rigid deductivism of the *homo œconomicus* model. In the neoclassical model, the (economic) preferences are inferred based on the model of rational expectations. Both Bachelier (the forerunner of EMH with his random gait hypothesis[34] of the price, or the efficienc of the financial market) and Samuelson (who arrived at the concept of random walk starting from other axiomatic premises), but especially Fama (the creator of EMH as we know it today), have used the theory of rational expectations as a basis of rationality,[35] a mathematical theory empirically wholly unjustified, leading to the EMH's test failure (or forgery, in the terminology of Karl Popper).

The behavioural perspective

The behavioural perspective, which could just as well be called the psychological perspective,[36] is initiated as a scientific research movement oriented against the *homo œconomicus* model (or neoclassical theory). Specificall , behaviourism tried to identify (and explain)[37] abnormalities occurring in empirical studies to test for EMH. The main cause of deviations from rational behaviour required by EHM is considered from two perspectives.

From the perspective of *rationality* – the real individual lacks the ability to be fully informed (by excluding transaction costs implied by searching information, condition axiomatically posed by EMH), and, even if it did, it lacks the ability to calculate the optimal decision under conditions of uncertainty (or even in more relaxed conditions of risk). The concept that encompasses these characteristics, *bounded rationality*, was developed by Herbert Simon in 1952 in his work *A Behavioural Theory of Rational Choice*[38] but did not catch on until Robert E. Lucas used it in his analysis of the Phillips curve.[39]

From the perspective of *emotion* – the individual decides not only on a rational basis but also on the basis of emotions. The main emotions in the individual decision process are fear and greed. Researchers in the field show that, in fact, effective rationality is a sui generis combination between (more or less limited) conscious calculation and emotion.[40] This introduces a strong idiosyncratic component in decision-making, but from the perspective of this study's research interest, the more important conclusion is that (economic) preferences are not interpersonally comparable because the emotion is completely subjective despite the fact that rationality is common (or a common inter-individual nucleus can be identified). From the point of view of the concept of adaptive preference, it results in the behaviourist vision that there is no kind of inter-individual commensurability, so the possibility of modelling and of prediction, is very low. However, the behaviourism (we repeat, without producing an authentic explanatory theory) argues that, in real behaviour, the preference will always adapt to both the individual specificity and the specificity of the concerned environment. This conclusion is, in fact, the 'spark' that has generated the following two perspectives of economic models that incorporate the concept of preference.

The institutional perspective

The institutional perspective (or normative) is also a reaction to the neoclassical economic model of human behaviour but from an exogenous direction of the individual, namely, from the direction of the normative framework of society. In essence, this perspective argues that the individual has an important constraint that he must respect when making a choice (i.e., take a decision), namely, the norms (not necessarily formal – i.e., those that are already codified and publicly announced). For example, hedge funds are less regulated than mutual funds, so the former have a higher margin of action than the others (on the market, individuals are either natural or legal persons). The most important aspect of the institutional perspective is that, having to comply with the norms, the economic behaviour (i.e., decisions on economic transactions) of the individual acquires a certain degree of predictability.[41] Of course, any degree of predictability is inconsistent with EMH, as it allows to obtain yields above market level, without incurring additional information costs and without taking risks above the average risk of the market (or without zero effect of the efficien market). The (new) institutional perspective is initially based on North[42] (1990); it gradually evolves into a research methodology and even into an (alleged) economic theory of growth and development, as well as a theory of economic decision-making. In the narrow sense of the term, *normative constraint* means the legal norm (e.g., a positive law), but, in a broad sense, it refers to any constraint – for example, observance of the von Neumann and Morgenstern (2007) axioms in decision-making on the expected utility is considered a normative conditional choice. In this sense, a decision based on aversion to loss (as in the case of behaviourism) is a non-normative choice.

The evolutionist (evolutionary) perspective

The scientific interest of this study is focused on the evolutionist (or evolutionary) perspective[43] underlying adaptive preference.

Economic preference is one of the 'predictors' of economic behaviour, in the sense that knowing the economic preferences of an individual, other individuals participating in the economic game (i.e., on the market) can orient their behaviour based on this prediction so as to maximize their own chances to win. Economic preference, however, serves, first of all, for the choice made by the individual concerned. If we reject the neoclassical conception of economic preference (which is given and invariant and is used to calculate the function of the expected utility on the basis of which the choice is made), then we arrive at the concept of adaptive preference – that is, a preference (or, more generally, a set of preferences) that is no longer invariant. Why adaptive preference is no longer invariant, in relation to what economic factors it varies, and aspects related to the permanent dynamics of adaptive preference are issues that are addressed by the evolutionary perspective of economic behaviour.

The evolutionary perspective is 'inspired' by biological evolutionism (currently known as Neo-Darwinism) – that is, it considers, first of all, 'natural' selection (in fact, it is a social selection; the natural predicate is used by authors to emphasize that here we are dealing with an invisible hand and not a deliberate action).[44] This selection is made by environment (e.g., by market). It is necessary to specify a crucial difference of natural selection in the economic market compared to natural biological selection: while biological natural selection considers the individual (physically) as such, natural economic selection considers the behaviours of individuals (either as individuals or as institutional aggregates – so-called legal entities).[45] Therefore, natural selection on the financial market has a replicator[46] – the economic behaviour of market participants (especially, of course, investors, either as individuals or as organizations/firms/companies).

The most important issue related to the evolutionary perspective on economic behaviour is that by itself, the label 'evolutionism' involves both the concept and the process of adaptation. In the specialty literature (including Lo's work from 2004 and in its 2017 edition, which introduces AMH – through terminological symmetry (and opposition) to the efficien market hypothesis (EMH), of Fama, from 1965 to 1970 (Fama, 1970)), the cause-and-effect issue in adapting preferences is relatively ambiguous: on the one hand, if we talk about adapting economic preferences, they can only adapt to changes in the (financial) market, but, on the other hand, the hypothesis is called adaptive markets, so it would involve adapting the (financial) market to the preferences of the economic actors involved. This ambiguity, as well as the fact that Lo's reference work abounds in empirical illustrative analysis intended to constitute arguments for AMH (although, in our opinion, there are more arguments against EMH, which is not equivalent logically nor empirically to argue in favour of AMH), but less in a systematic theorizing, possibly in a logical key, even if not axiomatic, will help us to realize, in a future research (in the second volume to be released), a co-evolutionary model of the

financial market, in which the economic preferences of the economic actors taken into account and the market (as a whole of the preferences revealed[47] of all the economic actors) are adjusted to each other, in a dynamic mechanism in which the cause and effect are passing continuously from one side to the other (using metaphors often used by the economists and even quantitative modelers, we have to deal with an 'arms race' or a 'prey-to-predator' relationship[48] between the individual and the market[49]).

The AMH and the EMH consider exclusively the adaptability and the efficienc of the market from the information point of view. However, this research will examine other (financial) market functioning factors that could be included in the analysis of the two mentioned hypotheses.

Setting of the problem

The purpose of this chapter is to clarify the term *adaptive preference*. So, we will focus on the AMH, which we will contrast with the EMH, so that the idea of adaptive preference that we will use in the rest of the research is free of ambiguities as much as possible.

The problem which we propose to solve can be described as a list of 11 topics that, when developed individually and in synergistic combination with one another, will lead to achieving provocative scientific results: (1) the logical content of the adaptive preference concept; (2) the typology of adaptive preference; (3) the three P's of total risk management from the perspective of adaptive preference; (4) double adaptivity on the financial market; (5) elasticity and plasticity in adaptive preference; (6) competitiveness, cooperativeness, and indifference in the kinematics of adaptive preference; (7) co-evolution in adaptive preference; (8) adaptive preference and automatic stabilizers; (9) adaptive preference and natural values on the financial market; (10) adaptive preference and double selection on the financial market; and (1) autopoietic adaptive preference.

Topic I: *The logical content of the concept of adaptive preference*. This section will investigate the possibility of stating a definition of the adaptive preference concept based on sufficienc predicates, with this definition serving as the foundation for all subsequent uses of the concept.

Topic II: *Typology of adaptive preference*. This section will examine the possibility of identifying some criteria for classifying adaptive preference (exclusively in the context of the financial market), and on the basis of these criteria, the corresponding classes of adaptive preferences will be proposed. Both the classification criteria and the resulting adaptive preference classes are the authors' own contributions, as these issues are not addressed in the specialty literature, although it is clear that the empirical testing of the different adaptive preference classes cannot be the same.

Topic III: *The three P's of total risk management from the perspective of adaptive preference*. In this section, for adaptive preference, a symmetric analysis will be realized with that realized for EMH on the three P's (prices, probabilities, preferences) (Lo, 1999; Farmer, 2002) of total risk management for the financial

market, in the context of AMH. Our research will extend the dyadic price-information approach (the favourite object of EMH testing) to the triadic price-information-preferences approach. Considering the model of the three P's, there will be an extension from the triadic model *price-probability-preference* to adjusted triadic model *price-probability-adaptive preference*.

Topic IV: *Double adaptability on the financial market*. This section will examine the 'game' between the adaptive preference of an economic actor and the variation of the financial market as an effect of the decisions of all economic actors on that market. The result of this section will be used to study co-evolutionary model that will be proposed by the research study for financial markets (in the second volume to be released).

Topic V: *Elasticity and plasticity in adaptive preference*. This section will examine the phenomena of elasticity and plasticity (the two properties/phenomena being antagonistic). The results of this section will be used to study the aspects of inertia/conservability and volatility/variability, both from the perspective of adaptive economic preference and from that of the financial market considered as an environment of the adaptive preference. This research topic, in the margin of clarifying the concept of adaptive preference, will be developed in the current conceptual momentum[50] which characterizes the different sub-episodes of maintaining the trend of the price (or yield) on the financial market (return clustering or fractional integration, in time series).

Topic VI: *Competitiveness, cooperativeness, and indifference in the kinematics of adaptive preference*. Adaptive preference, as a more realistic species of preference, characterizes the behaviour of each agent on the financial market and, at the same time, the aggregate behaviour of agents. This aggregate behaviour, called by some authors as macroeconomic behaviour or macro-behaviour, is, in fact, the impersonal behaviour of the market in relation to each of the individual agents (personal or organizational, as appropriate). The reciprocal relations between the adaptive preferences of the economic agents and the financial market can be of three types: (a) competitiveness relations – the change of an agent's preference negatively affects the isomorphic preference of another agent/agents; (b) cooperative relations – the change of an agent's preference positively affects the isomorphic preference of another/other agent/agents; and (c) indifferent relationships – the change of the preference of one agent does not affect the preference of another agent.

Topic VII: *Co-evolution in adaptive preference*. This issue is, in fact, closely linked to that discussed in Topic VI. The mutual affect between the behaviour of the economic agent and the behaviour of the financial market is subsumable to the concept of co-evolution. Co-evolution is, as the name suggests, a mutually caused/conditioned evolution. This causal-conditional reciprocity is achieved through adaptation-mutual selection between adaptive preference and environment. This connotation is retained even by the author who introduced the concept of adaptive market, namely, the AMH, Andrew Lo, by the fact that the market itself is considered adaptive, not just the economic preference.

Topic VIII: *Adaptive preference and automatic stabilizers*. The intervention of behaviourism in the economic analysis of the decision makes a large part of the 'rationality' of economic behaviour to be of subconscious origin – belief, preferences, emotions, and other such – which, of course, is combined with the rationality models. This means that a large part of the economic behaviour is of the automatic type; therefore, from a scientific point of view, it is interesting (and useful) to study the automatic stabilizers that work at least on the inertial (conservative) side of the economic behaviour, both natural stabilizers and normative (institutional) stabilizers.

Topic IX: *Adaptive preference and natural values on the financial market*. The concept of equilibrium does not disappear with the adoption of a more general perspective (and more realistic) of functioning of the financial market (such as the adaptive perspective). In fact, the equilibrium benchmark will always be necessary, as a thread of Ariadne, in economic analysis (whether it is associated with the optimal, as does neoclassical economic theory, or with the sufficient as does evolutionary economic theory). After all, as is well known, EMH itself is a never-ending trend in the economic system to reach equilibrium, that is, the state of information efficiency of the market

Topic X: *Adaptive preference and double selection on the financial market*. In the social/economic field, a double selection functions: (a) genetic (natural) selection and (b) cultural selection.[51] The two selections are cross-conditional, so the final selection of individuals (in fact, of the economic behaviours) is the combined effect of the two types of selection. In principle, cultural selection is done through normativity, and there is even an 'internal' selection between the two types of selection: genetic selection selects cultural selection, and cultural selection selects genetic selection (Bergh & Gowdy, 2000).

Topic XI: *Autopoietic adaptive preferences*. This section will examine the possibility of an autopoietic model (theory) of the financial market and of adaptive economic preference. The findings in this section will be used to create a proposal for this autopoietic financial model (in the second volume to be released). The autopoietic model of the financial market will be an original contribution of the authors to the specialty literature.

Each of the 11 topics in the margin of clarifying the concept of adaptive preference will be examined briefly in the following section, and some will be resumed in more detail later.

Discussion

Topic I: The logical content of the concept of adaptive preference

From a logical point of view, preference (as well as belief) is not a proper cause of the decision (and subsequent action) but a conditionality of the respective cause. Assume that an agent wishes to invest (purchase) a number of private shares (stocks). The final cause (i.e., the purpose) of this decision and the purchasing action is the gain of substantive (economic) utility. Whether or not he will make

the decision, whether this decision will be formulated in one way or another, all these features will depend on the preference of the decision, so the preference is not, in itself, the cause of the decision but acts conditional on the decision. For example, if the agent has a risk aversion, the decision will look one way, and if it does not, it will look different.

In essence, the preference simply changes subjective probability, or the expectation[52] that the agent associates (often subconsciously) with the intended event. This section will not make a pedantic (but ineffective) distinction between belief and preference, considering that preference is a revelation/objectification/manifestation of belief. As we have stated in section "The concept of economic preference", the economic preference simply assigns, subjectively (often, of course, even against the values indicated by the objective/ frequential probability), the highest probability of a 'preferred' event.[53] From the point of view of the subjective probability, the preference can be both a Bayesian *a priori* and an *a posteriori* probability because new information that is available to the agent who has already issued a subjective probability will change its initial value, according to Bayes rule, and will turn it into an *a posteriori* Bayes probability. Therefore, the process of 'a posteriorizing' the subjective probability issued on the basis of preference does not turn the latter into adaptive preference; it remains a standard preference (i.e., as in the EMH model, an invariant preference). Now, moving on to the concept of adaptive preference, it can be defined based on the following sufficiency predicates

- it is a *preference*, so it has all the properties (attributes) of a preference in the standard model: subjective – that is, public incommunicable at first hand – idiosyncratic – that is, incommensurable with the preferences of other individuals, and so on;
- it is *variable*,[54] according to the environment in which it is operationalized – by environment is meant the set of agents, institutions, processes, and so on in which the agent concerned acts;
- it is *acquired* – like the standard preference (although it is considered given at the level of the individual, it is not innate, but inculcated in the individual under environmental pressure), adaptive preference is acquired and hoarded (or not, as the case) following the individual's interaction with the environment. Of course, from a biological point of view, the preference (either standard or adaptive) is not transmitted to descendants, although, as we will see, from a cultural/social point of view, it is, in fact, transmitted;
- it is *transmitted* both interpersonal, through the contagion effect (herd effect), and inter-generational, through the normative framework. Impersonal transmission uses the memetic vehicle[55] (Dawkins, 2018), while inter-generational transmission uses the semetic vehicle[56] (Dinga et al., 2021);
- it is *inertial* – it manifests a certain 'resistance' to the environmental pressure so that its modification will occur only after a minimum amount, corresponding to a certain threshold, has accumulated (which cannot be determined theoretically, but only empirically). This 'conservatism' of adaptive preference

is useful from an evolutionary perspective and also ensures a relative predictability of adaptive preference, both for the analyst and for other participants to market transactions;

- it is *anticipatory* – being generated by the pressure of the environment, the adaptive preference also has (or acquires, in time) certain anticipatory 'skills'. These are the result of past experiences, in which some random anticipations were successful and, as a result, were retained through a trial-and-error learning process;
- it acts *heuristically* – adaptive preference (as well as standard preference, although neoclassical economic theory does not accept this) does not act rationally, i.e., by subsuming a model of rationality. The heuristic action is based on the above-mentioned trial-and-error. From a logical point of view, heuristics is the way to implement abduction[57] (as the standard preference in the EMH model acts deductively).

A problem of a conceptual nature, here, is the following: what is the origin of the preference, both the standard one and the adaptive one? The following important clarification must be made from the beginning: the natural inclinations (propensities), so to speak, of the individual, for example, the tendency to decide/act heuristically is not a preference but a genetic trait, of biological, not economic, or cultural origin. It remains, therefore, to consider that preference (of whatever kind) is an effect/result of the interaction of human nature with the environment (natural, economic, or general social/cultural). This origin of the preference must be accepted for both the standard preference and the so-called adaptive preference. Therefore, in principle, any economic preference is acquired, not innate – that is, it is acquired either by memetic mechanisms or by semetic mechanisms.[58]

The fact that EMH assumes that the set of preferences, together with their hierarchy, is given does not mean that preferences are considered unjustly and is only an axiomatic assumption intended to simplify reasoning and formal modelling.[59] As a result, in the 'correct' way, we must say that preferences can only be adaptive, but according to the current study, by the fact that preferences are adaptive, we will understand that preferences are no longer considered exogenous but are designed as the result of the interaction between a specific generation of preferences, which exists at a given time, and the environment. In other words, although not absolutely, as in the case of EMH, the set of preferences along with their lexicographical order will be considered as given during interaction with the environment – the difference from EMH is that the 'datum' of preferences is not rigid (in the sense of considering preferences as exogenous) but is relative – that is, they are endogenous to a large extent.

Topic II: Typology of adaptive preference

The specialty literature does not address the issue of a possible typology of adaptive preference (not even the author of the AMH, Andrew Lo, offers such a

typology). However, the present research must also address this issue, given its 'ambitions' to develop at least three theoretical models that are not systematically addressed (or not completed, even if there are some sporadic approaches) in the scientific literature on the functioning of financial market: the co-evolutionary model, the model of price or natural yield, and the autopoietic model.

In order to identify typologies of scientific interest (and praxiological, i.e., from the perspective of strategies usable in the financial transaction/investment), a system of classification criteria is necessary. Three such criteria, in our opinion, can exist as follows: (a) the criterion of the *cause* of adaptive preference, that is, the change of concerned preference; (b) the criterion of the *scope* of the adaptive preference, relative to the financial market (more precisely, relative to the agents trading on the market); and (c) the criterion of the *origin* of the adaptive preference.

On the basis of the cause

According to the cause criterion, there may be four categories of adaptive preferences:

- (a_1) adaptive preferences generated by *efficient* causes[60] – generally, these adaptive preferences are a result of how the market works (just as exaggerated, it can be said that are generated by the invisible hand). For example, preference for contrarian strategies (strategies that 'bet' in the opposite direction of the market moment[61]);
- (a_2) adaptive preferences generated by *material* causes – those preferences that are initiated or modified by substantive aspects of market functioning (such as substantive utility manifested in the form of excessive yield) – that is, yield above average market yield, and without taking risks or paying additional costs for the intended transaction: for example, preference for investing in value assets versus preference for investing in growth assets;
- (a_3) adaptive preferences generated by *formal* causes – those preferences that are initiated or modified by the normative or theoretical framework,[62] including traditions, customs, religious faith, or political attitudes: for example, preference for less legally regulated funds (such as hedge funds, a kind of hyper-active fund in the financial market), as the low level of regulation (and, consequently, a low level of public control[63]) allows them to exploit opportunities that, otherwise, would be inaccessible;
- (a_4) adaptive preferences generated by *final* causes – those preferences that aim at the purpose of the trading game. It should not be considered that the purpose of a financial transaction is always to obtain a surplus of profit (in the sense of either a gain above the market average – in the case of the same risk assumed and the same transaction cost – or a gain higher or lower than market average, but higher than the cost of the transaction or hedging the risk assumed above the average market risk):[64] for example, risk preference.[65]

According to the scope criterion

According to the scope criterion, there can be two categories of adaptive preferences:

- (b_1) adaptive preferences that characterize the individual by virtue *of human nature*. These preferences are the result/effect of the evolution of the individual human in his animal/biological component and are, in general, conditioned by survival. Being generated by human nature which, for most of the human history, involves an individual who has lived under the rule of fear and the danger of death, these preferences are common to all concrete individuals.[66] They are the ones who usually decide on prudential behaviour, risk minimization, and so on: for example, risk aversion in case of gain or, equivalent (Kahneman, 2012), preference for risk in the case of loss;[67]
- (b_2) adaptive preferences that characterize the individual by virtue *of human condition*.[68] These preferences are contextualized to individuals (or classes of individuals) by the economic, social, historical, political, and cultural environment in which they live and participate in financial transactions: for example, preference for the shares of small companies.[69]

By criterion of origin

According to the criterion of origin, there can be two categories of adaptive preferences:

- (c_1) exogenous adaptive preferences: These preferences originate from the functioning of the financial market, so they are generated (of course, in the psychological and cultural context of each individual) by the trading actions of the concerned individuals, representing pressure that the environment (the market) exerts on the behaviour of choice:[70] for example, adaptive preferences such as 'sour grapes' (Elster, 2017);
- (c_2) endogenous adaptive preferences: These preferences originate from the individual himself (of course, also in the interaction with the environment). E.g.: axiological adaptive preferences ('gain without work, generated by luck, is not moral').

Of course, a given preference can be 'classified' into several classes, as defined by the aforementioned criteria.

Topic III: The three P's of total risk management and the adaptive preference

In the specialty literature (Lo, 1999), the triad of the three P's of total risk management is retained[71] in financial market trading strategies: prices, probabilities, and preferences. The use of only one (or only two) of the three P's does not

cover the entire risk of the transaction (assuming we are not in uncertainty[72]) – for example, the Value at Risk (VaR) technique is based only on probabilities, and asset pricing techniques (either arbitrage or equilibrium) are based only on prices and probabilities. In fact, it is important to consider all three aspects of financial transaction: risk coverage (price), imminent risk (probability), and choosing the amount of risk assumed or choosing transaction as such (preference[73]). In the context of the present study, there are issues, which need to be clarified or at least set, regarding all three factors involved in the financial trading decision.

Concerning the price

The price that an economic agent is willing to pay for the purchase of a financial security (or that he would like to receive for the sale of such a title) must be in the 'correct' ratio (i.e., advantageous to him) with value (i.e., with the utility of use, in the language of Adam Smith, or with the value of use, in the language of Marx). The larger the gap between price and value (in the advantageous direction), the higher the return on the transaction. The price/value is established either on the base of arbitrage[74] or on the base of equality between supply and demand. Several pricing models have been developed: some based on neoclassical theory (e.g. CAPM[75]), while others on heterodox basis (e.g., evolutionary or adaptive models). During the present research, the price will be approached in a way based on the balance of demand – supply and from an evolutionary perspective (more precisely, co-evolutionary).

Concerning the probabilities

The issue of probabilities is a little more delicate, given that, in general, fina - cial strategies face uncertainty, not risk (see the final note 11 on the distinction between risk and uncertainty proposed by Frank Knight), or, more precisely, both uncertainty as well as risk. But the risk may be associated with frequential probabilities (or objectives ones, based on the archives of the event concerned), while uncertainty can be associated only with the subjective probability (whether they follow the axioms of the Kolmogorov theory of probability or not, as demonstrated by behaviourist studies – for example, the sum of the probabilities associated with the exhaustive distribution of events is not 1,[76] or even there are negative probabilities associated with events (Burgin & Meissner, 2012)[77]. It seems that the dominance of subjective probabilities (the most well-known, of course, probabilities based on the Bayesian rule) in financial analysis and the design of financial strategies are beginning to lead quantitative modelling in the financial field towards a Bayesian econometrics – an econometrics much simpler and more intelligible than it is based on frequential probabilities, although it requires a more massive use of the software, the most appropriate being, it seems, the one provided by Matlab.[78]

Concerning the preferences

The main aspect (from the perspective of the present research) of the three P's is, of course, that of the preference. We discussed earlier the general concept of preference, as well as (mainly) the special concept of adaptive preference. The way of integrating the three P's in the financial transaction decision or strategy can be described as in Figure 1.2. The assumptions considered in the description of this mechanism are the following:

- concerning *price*: price and value tend to be at the same level only asymptotically,[79] that is, they will, in principle, never coincide;
- concerning *probabilities*: probabilities will be of the subjective type (Bayes) and are not 'required' to verify either the axiom of positivity or that of the sum equal to 1 for an exhaustive field of events;
- concerning *preference*: preferences are mixed, endogenous-exogenous adaptive preferences,[80] which allows both the rigidity required by the relative predictability of the economic agent's behaviour and the flexibility required by the variability of preference as a function of environmental variability.

The problem of risk in economic choice can be avoided in at least two ways, with the 'price' of replacing a risky future with an uncertain future. Uncertainty (a field of uncertain events cannot be associated with any probability distribution of those events, except one based on *a priori* Bayes probabilities, formulated,

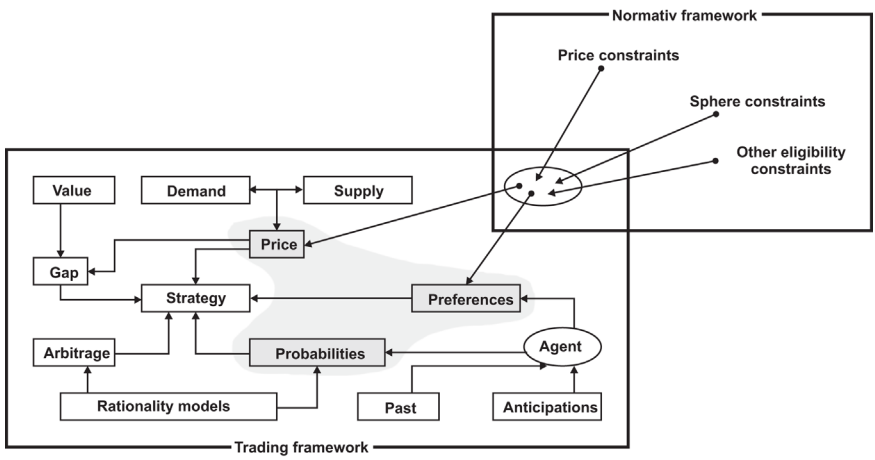

Figure 1.2 The abstract mechanism of the three P's.

Source: Authors.

in turn, on the basis of Laplace's principle of insufficien reason, i.e., with equal values everywhere) can be managed either by:

- antifragility – the agent's ability to obtain advantages from the very failure of his choice (Taleb, 2014), or by suffering a perturbation (either of internal or external origin);
- market modelling at intervals, from the perspective of game theory – such modelling would be exactly the purpose of replacing risk with uncertainty (Bernhard et al., 2013). Among the three P's of total risk management, preference is the most important and, in fact, least understood P (Lo, 2004).

Topic IV: Double adaptability on the financial market

We showed earlier that logically (and evolutionarily), no preference is innate (of course, we ignore instinct, which is innate, but which is not of the nature of preference, constituting, rather, a model of automatic rationality – specific to decision system 1 in Kahneman's theory). The conclusion is that any economic preference is a preference that has been generated by the interaction of the individual (economic agent, in our case) with the environment (with the financial market, in our case). When we talk about interaction, we are talking about a double causal relationship, which can manifest itself successively and, under certain conditions, simultaneously: a causal relationship from the environment to the individual and a causal relationship from the individual to the environment – we have here the so-called causality based on feedbacks of different orders/powers (Lewin & Volberda, 1999) and which, in specific situations, is of the type of circular causality.[81] In other words, we have not only an adaptation of the individual (more precisely, the behaviour of the individual) to the environment but also an adaptation of the environment to the individual (i.e., to his behaviour). Adapting the individual to the environment does not seem problematic, because the individual, based on his purpose, and in the way of his preference, aims to 'beat' the market, so he will adapt his preference in such a way to environmental pressures/challenges/changes to achieve, as far as possible, the purpose (how he will do this, or may do so, will be discussed in the present research). The adaptation of the environment to the individual seems, however, problematic, so we will present, below, some considerations in this area.

Based on the information at its disposal, and the proposed purpose, the individual economic agent makes decisions (or applies a strategy) to 'beat' the market – that is, to obtain a net return on his investment. Net gain is the difference between costs incurred – price, risk coverage, information collection/processing[82] – and the yield obtained. But any action on the market of the concerned individual represents an information (see signal theory) for other agents who, consequently, will update all the variables of interest: price, risk, obtainable yield, and so forth. All these variations in the behaviour of the involved agents constitute a variation of the market.

Market variation, as outlined earlier, will be reflected in the next stage (which may have a very short 'maturity' – days or even hours and, in the context of the digitalisation of the financial market, seconds or less) including the agent who 'caused' the change in behaviour throughout the market. This is the exact, operational meaning of the causal impact of the agent on the environment or, in other words, of the adaptation of the environment to the economic agent.[83]

This concept of double adaptability in the financial market is not, of course, 'smooth'; it involves inertia (the so-called moment[84] of the functioning of the financial market, identifiable, from a quantitative point of view by the autocorrelation technique) and, respectively, thresholds at which the accumulation of change pressure in the economic variables triggers changes of these variables.

In essence, the double adaptability on the financial market is the germ of the co-evolution process, which will be addressed, for a brief characterization, below, and which will be the basic logical and quantitative model of research. The double adaptability configures, in fact, a new order on the financial market, compared to the one established by the immutable balance expected by EMH (Lo, 2019).

Topic V: Elasticity and plasticity in adaptive preference

The variation of the parameters of the functioning of the financial market – for example, the prices or yields of the traded financial securities – is not linear,[85] neither proportionate nor instantaneous in relation to the cause of this variation – that is, with the emergence of new information (including the type of events, such as various announcements or reports made by market players). Of course, these behavioural aspects have been theorized[86] and observed empirically in a massive way. By the notions of elasticity and plasticity in the matter of adaptive preferences, we mean the following:

Elasticity

It is the property of a variable to characterize the functioning of the financial market (e.g., price) to show a certain resistance to the influence of change factors. Thus, in the case of EMH (regardless of its shape – weak, semi-strong, strong[87]), prices or yields are not elastic at all; they immediately take over the impact of information changes in the market. Empirical analyses performed to test the EMH have shown, however, that there is a particular complicated elasticity since this impact (the causes of this elasticity will be considered at the right time both in terms of causality and in terms of logical and quantitative modelling) and that prices reacted sub-proportional or supra-proportional to the informational impact.[88] The concept that shapes this elasticity is the *moment*. In principle, the moment of a series of time represents a number of successive records/observations of the parameter concerned (e.g., price), which are characterized by the maintenance of the historical trend/tendency: thus, an observation identifies a rising price, and the next price (or prices) follows the same trend (the same, of course, happens if an observation indicates a downward trend in the price). The moments (Satchell &

Grant, 2020) are considered market anomalies that possibly constitute opportunities for 'rational' investors[89] (Barberis & Thaler, 2012). From a logical point of view, the moments represent manifestations of inertiality in the kinematics of systems. The sub-proportional reaction means a sub-unit elasticity[90] (e.g., based on lags in retrieving/processing information) and the supra-proportional reaction means a supra-unitary elasticity (e.g., based on anticipation – leads – in retrieving/processing information).

Plasticity

Plasticity is an 'inverse' property of elasticity, in the sense that the new information appearing on the market is integrated into the price (instantly and completely, in the case of EMH, with 'errors' and 'memory' in the case of AMH). Therefore, the plasticity of the price (or other variable of interest on the financial market) simply means its reactivity or sensitivity to the variation of its cause. EMH considers information as the sole cause of price variation (in the three hypostases corresponding to the three forms of efficien market), while AMH accepts a wider range of causality because it includes other aspects in the economic agent's behaviour, such as the regulatory framework (see Figure 1.2) and, most important 'ingredient', the double adaptability discussed earlier. Logically, therefore, the price variation on the financial market is the result of an elasticity-plasticity mechanism (EP model) which, according to Andrew Lo's hope, could reconcile EMH with behavioural finance (more generally, behaviourism). To limit (and, of course, quite scholastic), the plasticity can be defined, through elasticity, as that case in which the elasticity is zero and, reciprocally, the elasticity can be defined as that case in which the plasticity is avoid. A synoptic representation of the EP mechanism is suggested in Figure 1.3.

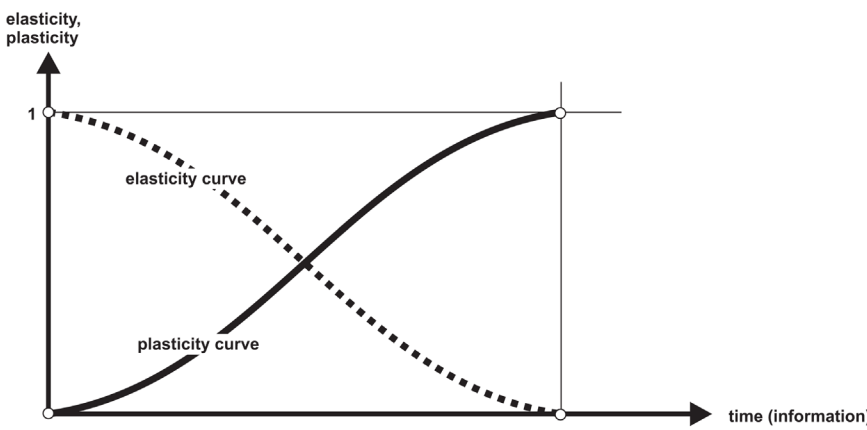

Figure 1.3 The abstract (stylized) mechanism of the EP model.

Source: Authors.

By specifying the discussion of elasticity and plasticity for the case of adaptive preference, the following characteristics could be considered:

- *firstly*, market efficienc is considered not only from an information perspective (as in the case of EMH) but also from a general causality/conditionality perspective. The matter, here, is whether any causality than the one manifested through information can be reduced, in fact, to information. In our view, the answer to such a question is negative, because preference is not only a result of rational deliberation so that only what is 'translated' into information constitutes input into the reasoning in question, but, as previously shown, it also represents a synergistic combination of rationality and emotion – but emotion is not informational;
- *secondly*, even from the point of view of the logic of the kinematics of adaptive preference, the information can be 'allocated' to plasticity and emotion to elasticity. Indeed, it can be said (of course, subject to conclusive empirical tests) that information is sometimes 'kept under wraps' (as in the case of the Kuhn's paradigm) until a certain accumulation of it generates a takeover in price. This lag (which can sometimes act in the mirror, as a lead) is a domination of plasticity by elasticity, which imposes certain thresholds of information accumulation (during this accumulation acting elasticity – i.e., moments of the time series) until the system swings – that is, plasticity occurs. In a way, price elasticity is directly proportional to the 'strength' of the adaptive preference, which means that the EP model from Figure 1.3 can be made more realistic by the representation in Figure 1.4.

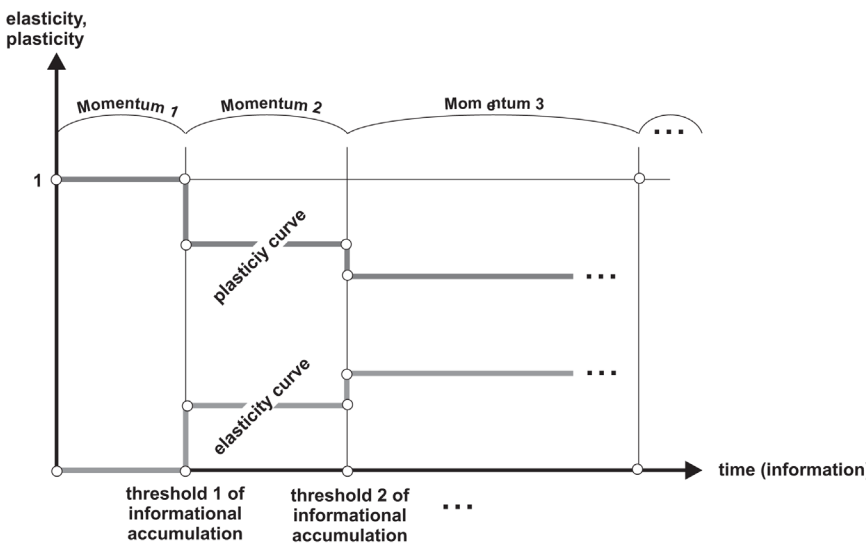

Figure 1.4 Threshold-adjusted mechanism of the EP model.

Source: Authors.

Topic VI: Competitiveness, cooperativeness, and indifference in the kinematics of adaptive preference

As the development of the analytical mechanism of adaptive preference will be done in the Chapter 2, in this section we will examine, in general, two fundamental aspects of this mechanism, namely, competitiveness and cooperativeness in the kinematics of adaptive preference (in fact, the following section of this study will develop this section to some extent).

Competitiveness refers to the situation in which, in a given market, two economic agents that interact improve each other's situation (gain, position, etc.) to the detriment of the other agent, and cooperativeness refers to the situation in which, in that market, the two agents who interact simultaneously improve their situation. Although not entirely equivalent, competitiveness can be understood as a zero-sum game (one agent wins, the other loses – win-loss), and cooperativeness – as a rising – sum game – win-win).[91] From a logical point of view, two more cases can be conceived: (a) the case of loss-loss: the interaction between two agents results in the simultaneous worsening of their situation; (b) a situation of indifference – the variation of the situation of one agent is not correlated, neither causally nor conditionally, with the variation of the situation of the other agent. In our opinion, case (a) could be named a double-counteract-action (the attempt to worsen the other's situation has a negative impact even on the initiator of this worsening – e.g., in a military situation in which one of the parties, in difficulty and withdrawing from battlefield, destroys transport and food infrastructure, which in turn will affect both sides, not just the opponent). Instead, case (b) seems to describe a situation that never occurs in real economic (financial) life. A synoptic picture of the four cases can be represented as in Table 1.1.

Let's examine the impact of the two processes (inter-actions) – win-win and win-loss – from the perspective of the concept of adaptive preference.

The win-win case

The realization of the win-win case (the only case of cooperativeness, from a logical point of view) leads to a preference validation effect, in the case of both agents from the interaction. Indeed, the gain generated by the decision based on a preference is an additional event that confirms the 'correctness' of the concerned

Table 1.1 Generic interaction between two economic agents.

		Agent 2	
		win	*loss*
Agent 1	*win*	cooperativeness	competitiveness
	loss	competitiveness	double-counteract

Source: Authors.

preference. As we said at the beginning of the study, a preference acts by increasing (or even maximizing) the subjective probability associated with a particular event in a given distribution of future events. The realization of that event will not only confirm that the value of the given probability to the event has been justified but will even increase this probability for the future.[92] The increase in probability is manifested by a strengthening of the concerned preference, by an increase in the agent's attachment to that preference. Therefore, the adaptability of the preference in the case of win-win is achieved by strengthening that preference. One of the (probably one of the best) explanations for strengthening the 'winning' preference refers to one of the behavioural anomalies (anomalies from the perspective of EMH), namely, over-confidence in one's own choices (Malkiel, 2003): the agent who wins as a result of his choice attributes his success to his own ability for anticipation, calculation, and so on, even though the gain could simply be the result of a contest of circumstances over which he had no control. This 'adjudication' of merit is also based on the agent's attachment to his own preference so that, in conditions of informational obscurity about the context of the concerned transaction, this preference is considered the effective cause of success. We can consider that, in the case of win, the preference becomes self-catalysing (positive feedback effect).

The win-loss case

In this case, we have a win case and a loss case. The win case was examined earlier. The win-loss case (which is symmetrical relative to economic agents) concerns competitiveness. The economic agent who loses in the competitive interaction will, of course, consider that the preference based on the choice made was not the correct one. Will he give up that preference? Because the situation is more complicated, the following considerations may be useful in reaching a conclusion:

- unlike the case of factual falsification of a hypothesis, the 'falsification' of the preference does not lead to its invalidation, in other words, a preference that has deceived expectations is not, *eo ipso*, rejected;
- what can we say, however, about the decline in confidence in the losing preference?

Firstly, it must be said that the decrease confidence in a preference can manifest itself in two ways:

- reducing the probability with which it is credited when the stochastic variable of the considered events is formed, maintaining the hierarchy of preferences;
- changing the hierarchy of preferences, in the sense that the compromised preference loses its place in the hierarchy, being 'degraded'; this can be accomplished by either maintaining the probability on which the concerned preference can grant it, if it is used in the choice, or by decreasing that probability; it seems that there could be a curve of indifference regarding the

penalty of the losing preference, between its movement in the hierarchy of preferences (*shift* type penalty) and its movement regarding the probability (*movement* type penalty).[93]

Secondly, there is probably a reluctance (subconscious, so not very sensitive to rational arguments) about the failure of a preference that generated losses as a result of the recommended choice. In other words, it is possible the agent may diminish the guilt of the preference, by trying to justify, other than by the failure of the preference, the loss suffered, or by considering that a single failure may be a simple bad luck and, consequently, willing to make another attempt with the concerned preference. The consequences are as follows:

- confidence in preference does not decrease, no matter how many failures it would register; however, such rigidity is unlikely, because, even if rational arguments do not matter too much in the face of subjective (or often evolutionary) attachment to a given preference, repeated failures signal an increasingly imminent danger: the danger of extinction of concerned behaviour (and, in some cases, even of the economic – or biological – extinction of the economic agent);
- there is an inertia of preference when confidence in preference ceases at a certain accumulation of choice failures, so there is an inertia of preference, but this inertia erodes either directly proportional to the number of failures or directly proportional to the average value of the loss generated by a failure.[94]

The generic impact of competitiveness on adaptive preference can be suggested as in Figure 1.5.

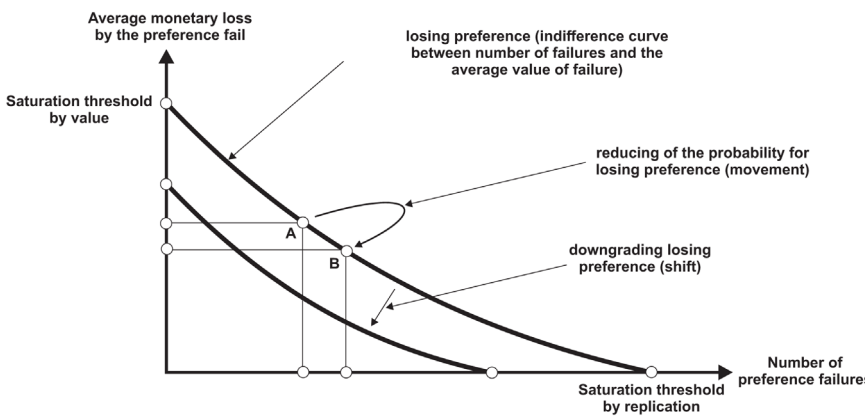

Figure 1.5 Variations as shift and as movement of the adaptive preference in the case of competitiveness.

Source: Authors.

Topic VII: Co-evolution in adaptive preference

The concept of co-evolution was proposed, in the field of biology, as a relationship between butterflies and flowers, by P. R. Erlich and P. H. Raven (Ehrlich & Raven, 1964), and in the socio-economic field by R. B. Norgaard (1994). This concept is still problematic, and although it has (apparently) a strong force of logical modelling (less quantitative, however), several researchers have different meanings about it. We will go over some details in order to clarify how this concept will be used in this study.

As the name implies, co-evolution refers to the inter-conditional evolution of two (or more) species. We consider here the abstract concept of species, not just that of biology, which refers to living things (e.g., a natural number is a species of integer, econometrics is a species of mathematical statistics, and a behaviour oriented towards risk seeking is a kind of economic behaviour). The two species react to each other, and, in this way, a tandem evolution takes place, a together evolution.

Co-evolution is different from co-adaptation (another concept used in evolutionary research). Co-adaptation only aims to modify (not necessarily in the sense of improvement) some characteristics of a species, in its effort to improve its fitness [95] Of course, under certain conditions, these changes of characteristics may be transmitted (genetically, in the case of living beings, or in other ways, in the case of other entities – theories, normative systems, behaviours, etc.) to offspring (often within-generational, not only inter-generational, as is the case with memetic replication).

From a conceptual point of view, it is, of course, interesting to analyse the relationship between co-evolution and co-adaptation. In our opinion, the essential difference between them is that while co-adaptation has a micro meaning, co-evolution has a macro meaning. Indeed, intense and relatively extensive co-adaptation will, at some point, go into co-evolution. In this way, co-adaptation can be seen as an analytical (micro) foundation of co-evolution (macro).[96] There are also authors who, referring exclusively to the concept of co-evolution, consider that it integrates, by itself, the micro level with the macro level (Lewin & Volberda, 1999), without the call for co-adaptation. There are also positions that claim, especially in the economic/social field, that micro co-evolution processes take place within the firm/agent (i.e., between its various components or levels) and macro co-evolution processes take place between the firm/agent and its niche (its environment) (McKelvey, 1997). It should be noted that there is a degree of adaptation/co-adaptation (or specialization/co-specialization – including in the field of agents trading on the financial market) over which the very survival (either of the individual as such or of his behaviour on the market) is undermined, because over-adaptation (or over-co-adaptation) is self-vulnerable (setting the relevant thresholds is, of course, a formidable scientific challenge, as it necessitates not only empirical estimates but also, it appears to us, analytical foundations).

Co-evolution involves cybernetic systems of order 2 that is, systems in respect of which the observer subject is himself a subsystem of that system[97] (Scott, 1994),

or systems that ensure the control of the control, or the cybernetics of the cybernetics. Thus, the quantitative (mathematical) modelling of co-evolution becomes more complicated but, obviously, at the same time, more realistic.

The issues discussed in Topic VI are helpful in developing some more analytical ideas on the co-evolution:

- *firstly*, there are, of course, co-evolutions of competitive type and cooperative one: an example of competitive co-evolution is that of prey-predator;[98] an example of cooperative co-evolution is that of parasite-host;[99]
- *secondly*, the co-evolution manifests itself only if three conditions of existence are verified (Schamp, 2010): (i) it is possible to differentiate the two species, (ii) there is simultaneity (co-existence of the two species), and (iii) there is mutual causality;
- *thirdly*, the co-evolution can be considered as the mechanism of chreod by which is engaged an inter-action of certain species to the other species;[100]
- *fourthly*, the co-evolution can be examined from the perspective of the used strategies (aspect that can be used, of course, in the economic analysis of the functioning of the financial market): (i) R-strategies: strategies to increase the number of descendants, with little attention to them – cyclical dynamics, characterized by instability, and (ii) K-strategies: strategies to reduce the number of descendants, with much attention to them – logistical dynamics, characterized by stability.[101]

From the point of view of the dynamics of the systems, the co-evolution can be credited with the function of double endogenization of the causality: the causality of one system is endogenized by the other system (and the same can be said about the second system).

A very interesting (and useful, especially in the context of digital globalization of the markets) distinction can be made between sympatric co-evolution and allopatric co-evolution. Sympatric co-evolution refers to the evolution of the species in the same ecological niche (specific to economic markets, such as the financial market or the labour market), which can lead, at first, to differences in individual behaviour within the same species. Allopatric co-evolution refers to the evolution of the same species in two different geographical areas, which also leads to individual differences in behaviour within the species.

Based on the clarification (in general lines, of course) of the concept of co-evolution, some main conclusions can be drawn immediately on adaptive preference in the presence of co-evolution:

- the pressure to change/adapt to economic preference is transmitted through the co-evolution channel and, to a lesser extent, through the co-adaptation channel;
- the actions and reactions inter-species or between the species and its niche (its environment) describe, in fact, the co-evolutive dynamics of the species involved or of the species and their environment;

- logically, it cannot be discerned, in relation to a given species, whether another species should be considered as such, that is, as a species, or as an environment of the given species. Both options are encountered in the specialty literature. Our view is that either any species opposable to a fixed species must be considered as the environment of the fixed species, or that the environment itself be considered a sui generis species. In any case, whatever position is taken, it must be maintained consistently throughout the analysis.

Topic VIII: Adaptive preference and automatic stabilizers

In general, in the face of disturbances, either internal or external, systems can behave in several remarkable ways:

1 *robustly*: the system resists disturbance without changing its state. By state of a system, we meant a vector that contains the most important coordinates (defining coordinates on the spatial, functional, behavioural identity, etc.) of the system concerned. If the system is robust, its state will not be changed by that disturbance. Of course, here too we must talk about the amount of disturbance, which is the product between intensity of the disturbance and its exercise duration, with allowable substitutions. Within certain limits, robustness manifests itself, therefore, as the inertiality. By the terminology introduced earlier (the relationship between elasticity and plasticity in the variation/adaptation of preference), we can also say that robustness is a kind of elasticity (there are moments in the kinematics of the state);
2 *resiliently/homeostatic*: the disturbance dislocates the system from the perspective of its state vector, but the system has the ability to return to the state prior to the disturbance. The resilient process is, in fact, somewhat more complicated (e.g., the tension generated by the disturbance is accumulated by the system, even if it returns to its previous state, so that, in time occurs an accumulation of this change tension (Dinga et al., 2011), i.e., a kind of fatigue of system is installed in ensuring the return from the impact of the disturbance), but, in principle, a resilient system returns to the previous state.[102] As suggested earlier, this system property is called homeostasis. In terms of kinematics/dynamics systems, a resilient/homeostatic system falls into category of stable systems;[103]
3 *homeorhesis*: refers to the system's property which, disrupted by their trajectory, have the ability to return to the path (this path will be considered as a *chreode* – i.e., a necessary trajectory, ensured by the fundamental principles of the nature and functioning of the system concerned). Unlike homeostasis, which recovers the state of a disturbed system, homeorhesis recovers the trajectory (chreode) of a system. From the point of view of system kinematics/dynamics, a homeorhesis system falls into the category of sustainable systems;
4 *antifragility*: the property of an antifragile system (Taleb, 2014) refers to the ability of a system to gain of the disturbance exerted to it. Therefore, an

antifragile system is not robust (not resistant to the disturbance) or homeostatic (not revert it to its previous state after perturbation occuring) or homeorhesis (does not return to the chreode path after the disturbance has occurred).

Based on this categorical classification, automatic stabilizers of the preference can only be discussed in relation to homeostasis and homeorhesis, respectively. The automatic stabilizer is a device which can be either institutional (introduced by norms) or 'natural', thus operating under free market mechanisms,[104] which has the function of maintaining/restoring the disturbed system to the state (homeostasis) or chreode (homeorhesis) prior to the impact of the disturbance. The automatic character of the action of a stabilizer must be understood as being opposed to its discretionary – that is, deliberative character.[105] From the point of view of the structure of an automatic stabilizer aiming at an economic preference, it must have the following five minimum components [106]

- an *initial position* (I): either as a state or as a propensity to chreode; the initial position is, in fact, the component that suffers the impact of the disturbance;
- a *memory* (M): necessary to keep a copy of the state (or chreode propensity) of the system in question, before the impact of the disturbance;
- an *observer* (O): necessary to construct either the new state or the new propensity generated by the impact of the disturbance;
- a *computer* (C): necessary to compare the new state (or chreode propensity) observed by the observer with the old state (or chreode propensity) preserved by memory;
- a *recuperator* (R): required to cancel the state or chreode gap found by the computer.

The general mechanism by which the automatic stabilizer acts in the case of adaptive preference is suggested in Figure 1.6.

Therefore, automatic stabilizers are of two categories: (i) state automatic stabilizers and (ii) process automatic stabilizers. The first category ensures the state invariance of the system, and the second ensures the trajectory (or flow) invariance of the system.

The relationship between adaptive preference and automatic stabilizer can be described as follows:

1 the disturbance, either internal or external, has the effect of dislocating the preference. This dislocation can occur either as a change in the place of preference in the hierarchy of preferences associated with an economic agent (or, more generally, in an economic behaviour) or as a change in the maximum probability allocated to a particular event (as we have shown, this is the concrete way in which preference plays its causal/conditional role in economic choice);

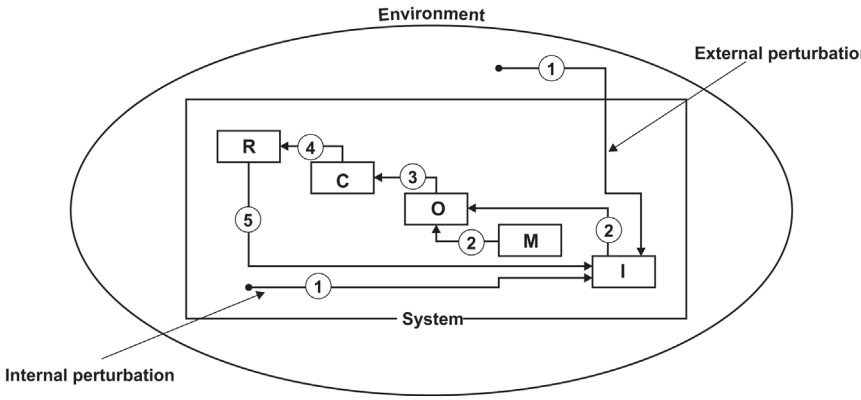

Figure 1.6 Mechanism of functioning of the automatic stabilizers.
Source: Authors.

2 according to Figure 1.6, a causal chain inside the system causes either the state or the propensity on the *chreode* to return the system to the initial state/propensity;
3 this means that the automatic stabilizers have the role, in essence, of preventing the adaptation of the preference to which it is 'pushing' the disturbance and, therefore, its preservation,[107] in other words, to reduce its adaptability;
4 the (potential) reduction of preference adaptability as a result of the operation of automatic stabilizers can, however, have an extremely important side effect – increasing the predictability of the causal or conditional impact of preference in economic choice.

Topic IX: Adaptive preference and natural values on the financial market

In this section we will (briefly) raise the issue of the relationship between adaptive preference and natural values in the financial market.

The concept of natural value in economics

The natural value of an economic variable is the value (expressed numerically and often monetary) of that variable that is generated by the associated causes, which are their size, rhythm, and 'natural' structure. The natural character of the causes refers to the fact that they are 'cleaned' of accidents, short-term circumstances, or other anomalies that can occur and damage the value of the concerned variable. For example, the price of a good is natural if the demand and supply for that good are not distorted either by monopolies (or, symmetrically, by monopsonies) or by

rules that make them no longer work 'naturally'. According to the well-known cobweb model, the transaction price for a good fluctuates, amortized (i.e., it approaches the equilibrium price). It is not the place (and none in the views of this paragraph) to delve deeper into the problem of the natural values of economic variables from a conceptual point of view, but we will make some methodological considerations that could be helpful in the following.

In order to determine the natural value of an economic variable (and this is done, of course, by quantitative methods/techniques), it is necessary to set a background condition. The equilibrium condition is the most common type of such condition: in the logical model in which the economic variable of interest is involved, an equilibrium condition is somehow put, and from this condition, the value of the variable is extracted (calculated). For example, the natural unemployment rate (either NAIRU or NAWRU)[108] is calculated by setting the condition of invariance to either inflation (the NAIRU case) or the wage (the NAWRU case). Or, analogously, the natural interest rate is calculated by setting certain equilibrium conditions for the monetary policy function known as the Taylor reaction function.[109] Similarly, the natural price of a good traded on the market is the price resulting from a stationary process.[110]

The equilibrium condition (or a logically equivalent condition) means a more important aspect from a theoretical perspective. This may be detailed as two properties: (a) long-term persistence – natural values are assumed to be the values that would be expected to objectify with the largest probability on the long term[111] (*Nota bene*: it is obvious that this property is one of the reasons why moments appear in time series); (b) the belief that this is the value that implies a fair game on the market or in the transaction, which leads to the idea that natural value has, in the last resort, also the meaning of fair economic value.

Since the equilibrium condition (or other equivalent condition) acts in the long run (is persistent), it is assumed that, from a conceptual point of view, the natural value of an economic variable is given (caused, maintained, regained) by its fundamentals. Of course, the problem of fundamentals requires, in fact, a theory (e.g., in EMH, the decisive fundamental is the available information).[112]

Natural values and the financial market

The natural values of the economic variables can be discussed, of course, in the context of the financial market. As it is known, both Samuelson (the creator of the martingale[113] within the neoclassical economic theory) and Fama (the creator of EMH, within the same neoclassical economic theory) considered the condition of economic equilibrium when the first referred to a correct game and the second referred to the efficien market. From a methodological/technical point of view, the natural values, for example, of a time series on the financial market, can be calculated by putting the condition of stationarity of that series (assuming, not entirely covered, that the invariance, over time, of the average, the variance, etc., of that series somehow captures the equilibrium condition on the market[114]). It is obvious that EMH aspires to capture the concept of price (or yield) naturally by its

fundamental condition that any information available to economic agents will be immediately and fully integrated into the variation of price (or yield). From another perspective, AMH also aspires to the same by making the condition that the price (or yield) adapt to the anomalies that necessarily result from the not completely rational behaviour of the agents. From a theoretical point of view, the distinction, relative to natural values, between the two hypotheses is not very big: thus, it is known that still the classical economists (Smith, Ricardo, Marx) accepted that the equilibrium price (i.e., the natural price) is only an asymptote which the transaction price tends towards. In this context, while EMH assumes that on the market is always exactly the equilibrium price (i.e., the natural price), AMH accepts that we are always looking for that natural price, usually by exploiting the anomalies introduced on the market by 'irrationals' (noisy traders).

Adaptive preference and financial market natural values

In this context, the following basic considerations can be made regarding the relationship between adaptive preference and the natural values of the financial market:

- on the financial market, there is always a gap (positive or negative) between the natural price and the transaction price;
- a fixed preference (as assumed by EMH) is very likely to face failures because it will not meet (in principle, never) the natural price but the transaction price;
- instead, the adaptive preference will change (adapt) according to the mentioned gap, so that, precisely through this adaptation, it will shrink that gap;[115]
- the adaptability of the preference could be, therefore, also be conceived from the perspective of its tendency to shrink the natural price (or yield) gap to the price (yield) associated with the transaction. If this gap could be associated with an entropic gradient concept, then AMH could be examined from this perspective as well.

Topic X: Adaptive preference and double selection on the financial market

The economic agents acting on the financial market are, firstly (and decisively), biological individuals; as a result, they are subject to (natural) genetic selection. Natural selection has three stages (or components): (a) genetic variation (mutation) – of contingent and random type;[116] (b) cumulative selection of the mutation (of necessary and oriented type); and (c) mutation retention, that is, its integration in trans-generational kinematics (of contingent and random type) – the so-called VSR model, that is, variation, selection, retention (Gong & Hassink, 2019). At the same time, individuals (more precisely, the economic behaviours of individuals) are also conditioned by the normative framework of society (including, at the microeconomic level, the normative framework of the financial market). This theory of combining natural selection with cultural selection is called

the theory of double inheritance (or double selection) (Galor & Moav, 2002).[117] Therefore, if the Darwinian evolutionary mechanism is governed by the genetic-ecological binomial (nature-nurture), in human society the genetic-ecological-cultural trinomial (nature-nurture-culture) must be accepted, which is rather the type of Lamarckian evolution. The two legacies[118] which shape the behaviour of the individuals on the financial market are inter-conditioned, the final effect of modelling economic behaviour being given by this inter-action. In relation to natural selection, cultural selection has the following main characteristics (these characteristics are retained, in particular, by van den Bergh and Gowdy (2000)):

- it is much faster than natural selection – indeed, norms and even values have a much higher frequency of change (or occurrence) than genetic variations (mutations). That is why it is said that, in the social field, we have a dominance of Lamarckism over Darwinism;[119]
- regarding the mechanism, cultural selection has to deal with much larger variations (mutations) than in the case of genetic selection;
- cultural variations (mutations) are almost not at all random (except for accidents or, sometimes, completely new visions of the model of society); they are either discretionary reactions or are inferred from sophisticated intellectual models;[120]
- because of its non-random nature, the transmission of cultural variation (mutation) is biased, specifica ly of three types: directly displacements/deviations – the old cultural model is attractive and remains persistent; indirect displacements/deviations – imitation, horizontally, of the minority;[121] frequency-dependent displacements/deviations – imitation of the majority is dominant;
- cultural selection is also based on so-called cultural altruism (not based on kinship).[122] Consequently, although less predictable than kinship-based behaviour, behaviour based on the common interest may nevertheless function as a predictor in economics;[123]
- gene-culture relationship (norms)[124] can be of two categories: (a) inter-active relationship, with the following species – (a_1) genetic mediation – gene modification affects cultural evolution; (a_2) cultural mediation – cultural change affects genetic evolution; (b) non inter-active relationship with three species – (b_1) enhancement – the cultural change strengthens the genetic evolution; (b_2) opposition – cultural change weakens genetic evolution; (b_3) neutrality – there are no reciprocal effects between genes and culture – for example, self-catalytic cycles (Alberch & Kauffman, 1994)[125] or meta-system transitions (Heylighen, 1999).

Regarding the relationship of adaptive preference with double selection on the financial market, the following can be noted:

- positive normativity (law norm) has a great power of selection, taking into account the cost/benefit ratio. Consequently, the economic preference will

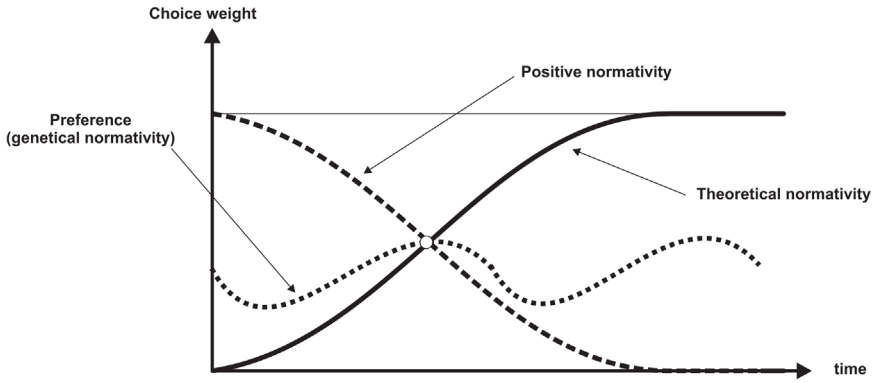

Figure 1.7 Weight of the three normativities in the economic choice.
Source: Authors.

adapt, with a high probability, to the positive normativity (see also Figure 1.2). One can examine the possible (and operational) relationship between two risk categories: (a) a probable risk – associated with a probability distribution of risky events from a purely economic perspective (here we have, we can say, a relationship yield – risk of the invisible hand); (b) a certain risk – associated with the positive normativity (here we have, we can say, a relationship yield – risk of the visible hand). The combination of *probable risk* and *certain risk* may be subject to quantitative modelling to provide a more realistic understanding of how adaptive preference relates to double selection from the financial market;

- theoretical normativity will play a secondary role, in relation to positive normativity, in the sense that rationality functions as a second filter in economic choice, after the first filter has acted – that is, preference. In the case of adaptive preference, a change of preference (by adaptation) will obviously condition the theoretical normativity;
- although adaptive preference is the first filter (both in logical and chronological order) in economic choice, in relation with the theoretical filte , it is also the most plastic filter – indeed, the rationality contained in the theoretical 'norms' are much less plastic (usually, they have a wide and long-term validity, conditioned only by the empirical testability of Popperian type). The relationship between the three filters of financial market behaviour can be represented as in Figure 1.7.

Topic XI: Autopoietic adaptive preference

Autopoiesis is a structural property of systems that ensures self-organization, self-repair (in case of damage caused by disturbances), and, ultimately, their

evolution. Autopoiesis has quite a few predicates in common with other general properties of systems, such as resilience, homeostasis, homeorhesis, coevolution, and even hormesis.[126] An autopoietic model of adaptive preference[127] implies the following:

- a *genotype*: a component of preference that can undergo a variation (mutation), either random or non-random (i.e., either random or deterministic). For this, the concept of preference must be subjected to a causal and structural analysis so that the component in question can be revealed. Probably, the genotype of the adaptive preference could be the maximum probability from the whole range of subjective probabilities that preference allocates in the case of the distribution of future events (or in terms of trading strategies) considered;
- a *phenotype*: that is, the replicator of preference. Probably in line with the proposal already made in the literature for the case of the company/organization (Nelson & Winter, 1985) – in this case, the organizational phenotype is, as we know, routine (see note 45, for details of the concept of organizational routine) – the phenotype of the adaptive preference could be the behaviour;
- a *selection* mechanism: the selection mechanism will be built, of course, by the interplay between adaptive preference ('wrapped' in objectified/revealed on the market behaviour) and the environment in which that behaviour works. Here all cases of selection, adaptation, and cooperation will be considered so as to be able to build/describe the general selection mechanism (natural-artificial);
- a *retention mechanism*: the retention of the variation/mutation selected at the level of adaptive preference refers to its intra-generational transmission (either by memes or semes; see notes 55 and 56) and to its inter-generational transmission (by genes or by memes or by semes). In fact, retention is the stage in which the concerned preference is considered to have completed the autopoietic adaptation process, that is, to have completed its adaptive exercise.

As we have shown earlier, AMH refers to (at least as a name)[128] the adaptability of the financial market. Of course, one can also discuss the adaptability of the market as an individual's strategy/behaviour because the market (or environment) can take the place of a generic agent (aggregate) in relation to the individual in question, but at least, in the present study, we will examine the adaptability of preference, so that, on this theoretical basis, we can elucidate the research.

A synoptic scheme of the relationship between adaptive preference and its autopoietic kinematics, which may lead to the concept of autopoietic adaptive preference, may be the one suggested by Figure 1.8.

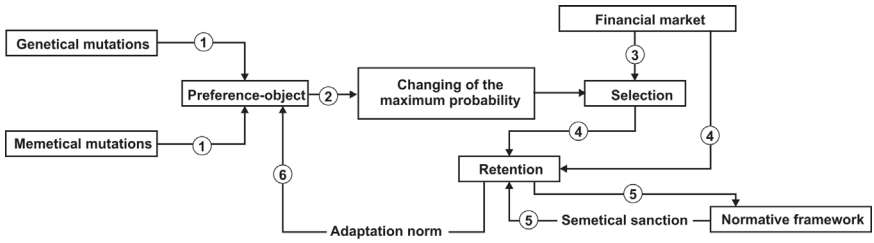

Figure 1.8 Autopoietic abstract model of adaptive preference.

Source: Authors.

Suggestions for future research topics

Based on the presentation in Chapter 1, we consider that scientific subjects in three research lines have potential for development:

I. In the field of financial markets

- is EHM a particular case of AMH?
- is there a mathematical relationship between the term (which should be) associated with a time series (short term, medium term, long term) and the frequency of observations in the series?
- how to identify/predict *Punctuated equilibrium*[129] in a time series (possibly by means of kinematic entropy)?
- formulation and examination of a possible MFH (*Mutual Fitness Hypothesis*) in case of modelling co-evolution on the financial market;
- AMH and *mate selection* strategy;
- the risk of over-adaptation/over-specialization (as speed or degree) of financial market preferences;
- adaptive preferences and reaction norms on the financial market;
- natural values and attractors in the price-value relationship;
- a phyidimetric[130] analysis of time series on the financial ma ket;
- towards an autopoietic model of the financial market;
- memes and semes in guiding on financial behaviour;
- heuristics and the principle of insufficien reasoning in financial behaviour.

II. In the field of mathematics applied to the financial market

- can the antifragility property of a strategy (beyond or outside of hedging) be formalized?
- can the fractality of price (or yield) fluctuations work as a predictor of a time series?

- symmetries and conservation laws in the functioning of the financial market;
- quasi-predictors in statistical invariants of the time series;
- assortativity gradients on the financial market: the haystack model.

III. In the field of economic theory

- is EMH testable (in the sense of Popperian falsifiability)?
- counter-factuality in the economic event – possibility, modality, relevance;
- collective commensalism in economic behaviour;
- institutionalism and the behavioural triad nature-nurture-culture;
- social capital and group selection in the economy;
- on eco-evolution adaptive preferences – institutional change;
- the economic environment as a model of rationality.

Notes

1 A valid inference from a model of rationality means an inference that verifies the three principles of bivalent logic: (a) the principle of identity, (b) the principle of non-contradiction, and (c) the principle of excluded middle. An invalid inference is an inference which is not valid.

2 The axioms of neoclassical economics theory were synthesized, among others, by David Colander, in his work '*The Death of Neoclassical Economics*', published in 2000, in the *Journal of the History of Economic Thought*, *22*(2).

3 The concept of expected utility is, however, introduced by neoclassical economic theory, the 'standard' being represented, as is well known, by the von Neumann–Morgenstern (VNM) model. The VNM model gives a utility function that is maximized using an objective (frequential) probability distribution. In this model, the preference had to simultaneously verify the following properties: completeness, transitivity, continuity, and independence. A certain relaxation of the concept of expected utility is performed by Leonard Savage, through the concept of subjective expected utility, in which the utility function is personal and the probabilities associated with events are subjective (Bayes type); see his work *The Foundations of Statistics*, New York, Wiley, 1954 (Barberis & Thaler, 2012).

4 The 'basic' emotions considered within behaviourism (as well as in the syntheses between neoclassical economics and behaviourism, such as biological or evolutionary models in the social plane, i.e., Edward Wilson's socio-biology) are fear and greed. On the two main emotions that accompany rational decision-making, see also Andrew Lo, 2013, '*Fear, Greed, and Financial Crises: A Cognitive Neurosciences Perspective*', in J. P. Fouque and J. Langsam, eds., *Handbook of Systemic Risk*, Cambridge University Press.

5 Bayesian probability is a type of subjective probability (there are other types, i.e., the propensity probability proposed by Karl Popper with reference to judgements, so not in set theory, such as the standard Kolmogorov model), which is used under conditions of uncertainty; hence, the complete lack of information on the field of future events. Bayesian probability is of two types: (a) *a priori* probability – the allocation of probabilities to events in conditions of uncertainty is done according to the principle of insufficien reason of Laplace, namely, allocating equal probability values to each event in the distribution; (b) *a posteriori* probability – the adjustment of the *a priori* probability on the basis of the new information obtained later. Thus, Bayesian probability is a conditional probability of the form $P\left(A|B\right) = \frac{P(B \mid A) \cdot P\left(A\right)}{P\left(B\right)}$.

6 There are, as is well known, *adaptive* anticipations (see Milton Friedman's model of the permanent income equation) which, however, are still under the rule of rationality.
7 It should be noted that individual economic preferences are considered given (i.e., exogenous and invariable) only in the neoclassical model (which also includes EMH – Efficien Market Hypothesis), while the alternative to EHM, that is, Adaptive Market Hypothesis (AMH), considers them endogenous, namely, from an evolutionary perspective.
8 The way in which principles (publicly assumed, i.e., through commitment) function as predictors of individual behaviour is dealt in an exhaustive way (and from a logical perspective) by Robert Nozick in *The Nature of Rationality*, published by Princeton University Press, in 1993.
9 We note that the meaning of the term *commensurability* is that of Kuhn's theory on the concept of paradigm, that is, it has nothing to do with the idea of measurement, meaning, simply, comparability from a point of view to be specified (and which, at the limit, can also be quantitative, of course).
10 Here we are talking about economic utility or substantive utility. As it is known, there are two other categories of utility: (a) evidential utility and (b) symbolic utility.
11 The distinction between risk and uncertainty was made by Frank H. Knight in 1921; see *Risk, Uncertainty and Profit*, Dover Publications, 2006.
12 By rational calculation we mean a validly inferred calculation from a pre-accepted model of rationality.
13 In essence, stochastic modelling based on Bayesian subjective probabilities is based on the principle of insufficien reason (subsequently, *a priori* probability is transformed into *a posteriori* probability based on new information obtained, leading to a conditional probability relationship).
14 We will not discuss in present material the issue of negative or supra-unit probabilities (important from an economic point of view, as there are negative variables – negative interest rate, negative inflation, i.e., deflation, negative growth, namely, economic decline, etc.). For an overview of the question of negative probabilities, see A. Khrennikov's *Interpretations of Probability*, published in 2009 by Walter de Gruyter, Berlin/New York. See also behaviourist studies in the financial field (i.e., in Andrew Lo's article, 'Reconciling Efficien Markets with Behavioral Finance: The Adaptive Markets Hypothesis', in *Journal of Investment Consulting*, *7*(2), 2005) in which the condition of sum equal to the unit of probabilities of a field of exclusive and exhaustive events s violated.
15 Strictly speaking, no economic (or, more generally, social) event is repeatable, because the variability of the environment and the 'profile' of the generic individual; therefore, the frequential probabilities are used abusively from a scientific point of view. However, as (in quantum mechanics) good predictions are obtained by using frequential probability, it is widely used in financial modelling (*Nota bene*: it does not exist so-called random distributions, because randomness does not allow patterns of behaviour, not even statistical type, as, however, is allowed by the stochastic).
16 Recall that the behaviourism, taken from behavioural psychology and cognitive psychology under the name of *behavioural economics* (for which several Nobel Prizes have been awarded in economics recently), infers preferences (or idiosyncratic motivations), precisely from observing externalized choices (e.g., through decisions/actions – consumption, production, investments).
17 For example, in the case of risk aversion or loss aversion (see Kahneman and Tversky's 'The Prospect Theory', Daniel Kahneman, in *Fast Thinking, Slow Thinking*, Public Publishing House, 2012), one or more probabilities may be more lower than the other (equal to each other) probabilities allocated on the basis of the principle of insufficient reason
18 The method of formalization (possibly even in an equational form) could be similar to the formalization of adaptive anticipation, used, for example, in Milton Friedman's permanent income equation or in the long-term Phillips curve equation.

19 We will see, as research progresses that, in fact, not only the individual (or his behaviour) adapts to the environment but also the environment adapts to the individual (or individual behaviour) through a dynamic harmonization (probing) of reciprocal reaction norms. The concept (taken from biology) of fitness applies, in fact, to the individual/environment pair or, more generally, to the individual/environment behaviour pair.

20 Obviously, at a later time (which is within another temporal 'cut'), the roles between the two entities change each other. The consideration of more than two entities, although it seems to represent a generalization of the problem, in reality is not: indeed, everything that differs from the adaptant can be considered as representing the adaptar; therefore, from a logical point of view, there will always be two and only two entities that enter into the adaptation relationship.

21 Here we are in the territory of the notion of scientificit , which gives a research result a degree of scientificity directly proportional to the degree of non-contextualization of that result. Analytical expressions are always more de-contextualized than expressions that have numerical determination/conditioning, such as expressions used in econometrics.

22 This property of versatility (and, in fact, binary symmetry) that we will see as crucial in discussing the concept (and mechanism) of co-evolution may lead to the idea of cyclicality regarding the adaptive market (proposed by Lo), for example, in terms of financial market investment strategies Lo, 2004).

23 Sporadic though not decisive, there are also studies that take into account the change of preferences, but (very importantly) not as a result of their exercise in decision-making and action but as an autonomous change process, for example, the so-called hyperbolic discounting of preferences in time (Laibson, 1997).

24 In some studies, the analogies with the biological realm (from an evolutionary perspective) are even direct (see Victor Niederhoffe , 1997, V. *Education of a Speculator*, New York, John Wiley & Sons), which identifies in the financial market: 'herbivores' (dealers), 'carnivores' (speculators), and decomposers (common traders and bankrupt investors).

25 We recall that natural experiment means the experiment that is observed without the observer interacting (influencing, disturbing, etc.) with the experiment in question (this is called a von Neumann-type experiment). The unnatural experiment should be called an artificial experiment or a disturbed experiment.

26 The type 1 error refers to the rejection of the null hypothesis when it is true (it rejects the hypothesis that the animal approaching me is a predator, which makes it impossible to reason later on the type 1 error), and type 2 error refers to the admission of the null hypothesis when it is false (we accept that the log approaching me is a constricting snake, and we give ourselves a chance to reason later on the null hypothesis error theory) (Thomas Andren, 2014, *Econometrics*, Thomas Andren & Ventus Publishing ApS).

27 Kahneman (2012) refers to system 2 as the decision system (brain) that makes decisions on a rational basis (sequential, slow, based on inference – so-called slow thinking), respectively to system 1 as the decision system (brain) which makes decisions on a subconscious basis (non-sequential, fast, based on behavioural automatisms).

28 As we will see, during the research, adaptive preference is essentially based on the possibility of a reciprocal, dynamic, and reversible transfer between the model of rationality and preference; there is, of course, the possibility that a decision is the result of a sui generis combination between the model of rationality and preference in its margin. Or, as it is said in the specialty literature, the rationality presupposes emotion (see Lo, 2019, Chapter 4: 'to be fully rational, we need emotion'; also, Damasio (1999)) – of course, this means that artificial intelligence can never be fully rational, although it is always optimized.

29 The lexicographical choice (or hierarchy) is that choice (or establishment – of principles, criteria, hierarchies, etc.) which, in turn, is not established on the basis of logical criteria nor is it extracted from a model of rationality. It is obvious that preference (economic or otherwise) can only be associated with a lexicographical choice; otherwise it would not be preference but rather a model of rationality.

30 Of course, here comes the issue of the so-called temporal discount, for example, the hyperbolic discount, which allows for variation of preference (in intensity or in hierarchy) and which will be commented on at that time.

31 Quantification (concept introduced by William Hamilton, the inventor of quaternions) means, in the proper sense of the term, discretization (the concept and term as such come from quantum mechanics, and etymologically, they come from Latin: *quantus* (quantity, size) and *making* (doing)). Even as per the *Cambridge English Dictionary*, it means the measurement, while *The Explanatory Dictionary of the Romanian Language* (EDRL) states correctly that it is a matter of discretization or of asserting the discontinuous character of a predicate.

32 We will show, however, that adaptive preference is not, as such, taken from the environment but is the result of an adjustment of an endogenous preference, under the empire of the environment.

33 Compared to the four approaches of the concept of adaptive preference, the approach proposed by the present research can be called the auto-poetic perspective (not overlapping, as it seemed *prima facie*, the evolutionary or biological perspective, developed, in general, although not decisive, in our opinion, since 2004).

34 It seems that before Bachelier, Girolamo Cardano spoke about random walking in 1565 (*Liber de Ludo Aleae*, meaning *The Book of Games of Chance*), and before Fama, in addition to Samuelson, there were other references to this concept: Markovitz (optimal portfolio), Sharpe (Capital Asset Pricing Model – CAPM), Black-Scholes model, Merton (option price); see Andrew Lo (2019).

35 The concept of rational anticipation (unfortunately, many analysts confuse them with rational expectations) was introduced by John F. Muth in 1961 with his paper 'Rational Expectations and the Theory of Price Movements', published in *Econometrica*, 29, a concept that refers to rational anticipations (the difference from rational expectations – which only works in the Bayesian model – is that rational anticipations are inferred/inferable from a model of rationality, for example, the logical model *homo œconomicus*, while rational expectations are exclusively subjective. The predicate of 'rational' associated with the subject 'expectations' refers to the fact that expectations are based, in this case, on the principle of insufficient reason of Laplace

36 Behaviourism is not, however, a pan-psychologism, just as neoclassicism is, in fact, a pan-mathematism.

37 Although several Nobel Prizes have been awarded for behaviourist research (see Kahneman, with the book mentioned, respectively; Thaler, with the book *Nudge* (the book of niches for better decisions related to health, wealth, and happiness), Publica Publishing House, 2016), this movement has not yet produced a theory (i.e., a hypothetical-deductive system) in the field of economics (more precisely, in the field of microeconomics) (Lo, 2019).

38 Explicitly satisficing, Simon dealt with bounded rationality in *Models of Man*, New York, John Wiley, 1957.

39 Like Keynes (regarding Michał Kalecki, or Karl Marx, or Frank Knight), Lucas never explicitly acknowledged Simon's 'inspiration' in this matter.

40 There are, however, a number of myths about EMH, which have resulted in an explosion of 'scientific' articles testing this financial market model but which, obviously, neither reject nor corroborate the model in question: *myth 1*: EMH implies that investors cannot beat the market (false); *myth 2*: any attempt to make predictions on the market is doomed to failure (false); *myth 3*: new information is always fully integrated

into the price (false); *myth 4*: all investors must be correctly informed and able to process information (false) (Clarke et al., 2001).

41 Robert Nozick (in the paper cited in note 8) argues that assumption of a principle (along with publicly announcing a commitment to that principle) works, for other members of society, as a predictor of the behaviour of the one who assumed that principle (*Nota bene*: the utility generated by assuming the principles of behaviour is called by the author *symbolic utility*, which is added to the other two types of known utilities: substantive or economic utility and, respectively, evidentially or probative utility).

42 Douglass North (1990) is also considered the 'grandfather' of Cliometry (its 'parents' being considered two of his students who organized the Conference at Purdue University, USA, in 1960). At that conference, this method of research was born, which combines the narrative study of the history of economics with its quantitative examination (usually using econometric techniques). Cliometry is also used in the sense of the new history of economics (see, here, Claude Diebolt and Michael Haupert, *Handbook of Cliometrics*, 2nd ed., Springer, 2016).

43 It can easily be shown that institutionalism is a kind of evolutionism. The predicate that must be removed from the definiti n of institutionalism (as a species) to arrive at the definition of evolutionism (as a genus) is the cultural (positive) character of the norm/institution – evolutionism also accepts natural (non-positive) 'norms' such as genetic code.

44 However, institutionalism, which, as noted in note 43, is a kind of evolutionism, also accepts the visible hand – manifested by the positive norm or the general normative framework. Probably a more appropriate name for this type of natural selection could be 'cultural selection' because economic behaviour is a cultural fact. Such a name, however, would mislead those who are not accustomed to the jargon of the researcher, so for now, we also opt for the phrase 'natural selection'.

45 One of the propositions made in the field of evolutionary economics (see Nelson and Winter in their work *An Evolutionary Theory of Economic Change*, published in 1990 by Belknap Press) is that, at the microeconomic level, what is reproduced from an evolutionary point of view is *routine* (a concept aimed at a mode of production, integrating technology, management, organizational culture, etc.), that is, conceptually, a behaviour (*Nota bene*: the equivalent concept in Marxist economic theory would be the production mode – i.e., integration of the productive forces with the relations of production – with the important difference that routine refers to the economic organization, while the mode of production refers to the whole society and even to the whole humanity). Regarding the financial market, Andrew Lo, in his paper, which we will refer to, *Adaptive Markets: Financial Evolution at the Speed of Thought* (Princeton University Press, 2004, 2019) refers, *expressis verbis*, to the fact that natural selection manifests itself on behaviours (e.g., on investment strategies).

46 In the language of biological evolutionism, the replicator refers to the phenotype (natural selection is exercised over the phenotype, which is the adult individual of the species concerned), while the mutation occurs in the genotype. We mention that the AMH (advanced by Andrew Lo in 2004) considers as a replicator the strategy adopted by the economic actor (either in his own name or as an agent of a principal – see agent theory). However, Dawkins thinks the replicator is the genotype – either gene or meme. Discussion can continue, but we will wait for a more provocative context to do that.

47 The concept of revealed preference, introduced in Economics by Paul Samuelson in 1938, in his work 'A Note on the Pure Theory of Consumers', Behavior', in *Economica*, New Series *5*(17), and resumed ten years later in 'Consumption Theory in Terms of Revealed Preference' in *Economica*, New Series *15*(60) is the one known in the speciality literature, namely, that preference which is objectified in decision-making

or action acts (e.g., in conducting transactions). The revealed preference avoids psychologism (which is especially prevalent in behaviourism) accepting as preferences only those that are manifested, that is, which are revealed on the market. It is what can be called a black-box approach, in which the individual's preference is judged only in terms of entry (cause) and exit (effect) in economic behaviou .

48 Here we have the famous Lotka-Volterra equations of the 'prey-predator' relationship, which the research will use (and, as far as possible, develop/adapt to the specific problems of the financial market).

49 Despite the excessive emphasis on the competitive relationship in modelling (logical and quantitative) the economic process, research will try to model the impact of adaptive preference also from the perspective of the cooperative relationship, dominant, in our opinion, in economic phenomenology.

50 In a series of times, the moment refers to the duration within which the autocorrelation of the observations in the series is non-zero and retains its algebraic sign.

51 In fact, there is the so-called genetic-ecological binomial (nature-nurture) which works, in general, in the case of living beings, to which, in the human field (social, economic, political), the term *culture* must be added so that we have a trinomial: nature-nurture-culture.

52 A distinction must be made between subjective expectation and mathematical expectation. Subjective expectation is a desire that is not necessarily framed in a stochastic distribution of the field of future events, while mathematical expectation is a precisely calculated numerical quantity; it is, in fact, what is called mathematical or average expectation, or moment of order 1 of the stochastic variable – called by some analysts, as we say, wrongly, random variable – which assigns probabilities, either frequential or Bayesian, to the events in question: $E(X)=\sum_{i=1}^{n}(x_i \cdot p_i)$, where x_i is the numerical value given to the occurrence of the stochastic event i and p_i is the probability-associated to the stochastic event i. Of course, as per the axioms theory, Kolmogorov (i.e.,based on set theory) probabilities are $\sum_{i=1}^{n} p_i = 1$ and $0 \leq p_i \leq 1$. As for n it can be finite or infinite but countable (i.e., can only be a maximum integer, usually it is natural) (Brooks, 2014; Koop, 2003).

53 See also the concept of *wishful thinking*, introduced by Robert Shiller in 2002 in 'Bubbles, Human Judgment, and Expert Opinion', in *Financial Analysts Journal, 58*(3) (by Stephen J. Brown, 'The Efficien Market Hypothesis, the Financial Analysts Journal, and the Professional Status of Investment Management', in *Financial Analysts Journal*, https://doi.org/10.1080/0015198X.2020.1734375).

54 The fact that any preference is variable is so obvious from both each individual experience and demonstrated (through scientifically credible experiments) by behaviourism (on the basis of cognitive psychology). This is known, of course, to EMH followers, but out of a (laudable, in fact) desire to maintain the axiomatic character of the model, based on neoclassical economics, they are obliged to 'decree' the invariant nature of preference.

55 Meme is a heuristic, behavioural 'device' that induces an ostensive learning, both intra-generational and inter-generational. It is a vehicle for behavioural (or functional) inheritance, just as the gene is a vehicle for biological (or structural) inheritance. The concept of meme was introduced by the radical evolutionary biologist Richard Dawkins, in his work *The Selfish Gene*.

56 Seme is defined, in a strictly operational manne , as an institutionally coded meme.

57 It is very easy to confuse an inductive approach with an abductive one, but in most cases, the procedure is abductive – that is, starting from a single particular case or

from a small number of particular cases, far to covering most cases, the most plausible explanation is issued, and then efforts are made to reject that explanation.

58 There is research that seeks to find genetic causes for economic behaviour – for example, research based on neuroscience and forming the so-called neuroeconomics (Loewenstein et al., 2008).

59 For example, AMH is considered an EMH theory with 'friction' (Svensson & Soteriou, 2017), by analogy with the fact that, in Newtonian physics, mechanical motion is first studied in the ideal case, that is, ignoring the friction which, however, is added later, in an attempt to give more predictive force to the law of motion in question.

60 In Aristotelian terminology (still valid after two and a half millennia), there are four categories of causes (all extracted from the principle of causality): (a) efficac cause – the cause which, by its direct action, that is, effective, therefore somewhat of an energetic nature, generates the modification (adaptation) of that preference; (b) material cause – the cause which, from a substantive point of view, generates that preference; (c) formal cause – the cause which, from a conditional perspective (e.g., an equation, a norm, a plan) generates the preference; and (d) the final cause, or purpose – the cause which, from the perspective of the finality of the action, generates that preference.

61 Market moment (see also note 50) means that window (duration) in the function of the market in which the monitored variable (e.g., price, yield) is serially correlated (either positively or negatively) with its previous values recorded in the time series (Satchell & Grant, 2020).

62 A theory is as strong a normative as a positive norm (a legal regulation), with the diffe - ence that the normativism of the theory is of an intellectual (conceptual) nature, in that the normativism of the positive law is of a legal nature. In other words, the normativism of the theory is optional, while the normativism of the positive law is imperative.

63 Following the crises of 1987 and 2007, respectively, the obligation to submit to public institutions for financial market monitoring was introduced, even in the case of less regulated organizations, reports which, to some extent, increase public control over them (Lo, 2019).

64 Moreover, although the study will not address this aspect at all, there may be cases (rather insular) in which the aim is not even to obtain a substantive utility but a symbolic one (e.g., the position of 'guru' of private finance – see the case of Soros or Buffet) or even a pure evidence (e.g., demonstration that he is able to predict the market, so beat it, to use the language used in the EMH margin – *to beat market*).

65 The positive and strong correlation between risk and return (as well as between individual/specific risk and market/systematic risk – see standard CAPM methodology) is not always maintained in EMH-based empirical analyses (and therefore more is not maintained in the case of AMH) (Alajbeg et al., 2012).

66 It seems that, for the most part, such preferences are subconscious in nature, precisely as an effect of their evolutionary acquisition and, therefore, as a result of their entry, more or less, into the genetic dowry of the human individual, which makes them replicable through the gene vehicle.

67 We recall that these preferences are discussed in the so-called prospectus theory proposed by Kahneman and Tversky.

68 Human nature and the human condition have the following semantic relationship (in general): the condition human is culturally conditioned or filtered human nature.

69 There are empirical studies that seem to indicate that the rate of return of small firms (at least in the short term) is higher than that of large firms (regardless of whether or not it is above average market yield) (Leković, 2018) – called the *size effect*.

70 There is no contradiction here with the fundamental principle of adaptive preference, which is that it is endogenous: the (partially) exogenous origin of adaptive preference has a contextual, rather than generative, meaning that the impact of exogenous elements is constantly and totally endogenized.

71 The concept of total risk management is introduced in the literature by Andrew Lo (1999), apparently at the suggestion of Zvi Bodie, an American economist specialized in pensions.
72 Uncertainty, as is well known, does not allow the calculation of any risk, as it does not allow the allocation of frequential probabilities (but only possibly Bayesian probabilities).
73 It appears that preference is not 'captured' in some *asset pricing* models, such as the Black-Scholes-Merton (BSM) model for pricing financial options, as the BSM model is an arbitrage model, not an equilibrium one (only demand-supply equilibrium models allow the introduction of preference).
74 Arbitrage is that financial strategy that leads to returns above the cost required by pricing or, equivalently, returns above the average market return at no additional cost to the average market cost.
75 Capital Asset Pricing Model, a technique for establishing an asset's 'correct' price based on the link between systematic risk (β) and expected return (or expected utility).
76 See, for example, the article of Mark Burgin and Gunter Meissner: 'Larger Than One Probabilities in Mathematical and Practical Finance', in *Review of Economics & Finance*, 2012 (Burgin & Meissner, 2012).
77 In our view, negative probabilities could be attributed to the existence of an aversion to the occurrence of a particular event. As for non-compliance with the axiom that the sum of the probabilities allocated to all events in the distribution should be 1, this is a more difficul (and, at the same time, more interesting) issue that will be examined at that time.
78 In fact, in addition to frequential and subjective probabilities (both types being elaborated on the basis of set theory), there is another type of probability that refers to judgements (e.g., probabilistic syllogisms, still discussed by Aristotle), namely, the propensity probabilities. The first discussion of propensity probabilities was generated by the semiotician Charles Sanders Peirce (see Arthur W. Burks, *Chance, Cause and Reason: An Inquiry into the Nature of Scientific Evidence*, University of Chicago Press, 1978), but there is also a theory in matter proposed by the philosopher of science Karl Popper (see *World of Propensities*, Thoemmes Press, 1990). Although fina - cial market modelling could also be associated with propensity probabilities (as it was recently associated with Bayesian probability), this type of probability will not be discussed in the economy of this study.
79 The idea conveyed (too easily and probably carelessly) in the specialty literature that although in the short term, there is a gap between price and value, in the long run, it tends to disappear (precisely through its exploitation by 'informed' or 'rational' investors) should be avoided. This is because it implies, logically, the idea that at some point, in the long run, the market becomes efficien (in the sense of EMH), which is false – at any point in its functioning the market (at least the financial one, which is, for the most part, a speculative market, either in arbitrage or in equilibrium) must provide opportunities to be 'beaten'; otherwise it would disappear (Grossman & Stiglitz, 1980).
80 The idea of simultaneous endogenous-exogenous character has long been present in the specialty literature. For example, the issue of co-evolution (which is one of the main objectives of this research) is addressed in the theory of organization, where the environment is considered both endogenous and exogenous to the organization (i.e., not only a reactive adaptation of the organization is accepted to the environment but also the creation of the environment by the organization) (Weick, 2015).
81 Circular causality is that causality in which the cause and effect transform, successively, relative to the same entities involved in the causal relationship, from one to another.

82 For example, using a financial transaction expert to apply various sophisticated mathematical models to substantiate the decision (or, more often, to justify the fee).

83 Of course, as suggested in Figure 1.2, there are two components of the environment that are modified by the agent: the transactional environment, explained earlier, and the normative environment: for example, if a commercial bank signals a risk (possibly systemic, if is an organization with a significant exposure share) by far and persistently exceeding leverage, then it is possible that the capital requirement will be increased and so forth.

84 Not to be confused with the concept of moment from mathematical statistics (respectively from *Econometrics*), which calculates different indicators of stochastic distribution in time series – average, as moment of degree 1; variance, as moment of degree 2; asymmetry, as moment of degree 3; flattening, as moment of degree 4.

85 We recall that the EMH hypothesis accepts linearity in modelling the relationship between risk and return (see Stefano Posenato, *Adaptive Market Hypothesis: A New Point in Finance evolution*, CA' Foscari University of Venice, 2016), for example, in CAPM (Leković, 2018).

86 For example, through martingales (a theory of pricing in correct conditions of the game – fair game) that can be nonlinear (Alajbeg et al., 2012).

87 The three forms of functioning of the informational efficienc of the market were proposed by Fama (Fama, 1970), and these are (a) poorly efficien market: prices include all past and current information; (b) semi-efficien market: prices include all publicly available information; and (c) highly efficien market: prices include both public and private information (including 'inside' information).

88 For obvious reasons, behaviourism has reversed the causal relationship here: the economic agent, according to pan-psychological behaviourists, is the one who reacts nonlinearly (e.g., by over-reaction or under-reaction) to price variation. Prices, obviously, alter solely as a result of the reactions of economic agents on the market.

89 'Rational' agents are those agents who are able to take and process information so that it is included in the price ('irrational' agents are agents who are not 'rational'; they represent the so-called creators or traders of noise – in a statistical sense, i.e., exactly those agents who generate opportunities for 'rational' agents (called arbitragers) that they manage to 'beat' the market. In another sense, as we shall see, what in EMH is called irrationality represents (in AMH) an adaptive rationality (Alajbeg et al., 2012).

90 The calculation method of the coefficien of elasticity can be taken from the concept of elasticity generally used in standard economic theory (neoclassical, of type Economics): $e = \frac{\Delta y}{y} / \frac{\Delta x}{x}$ (in the continuous case we have: $e = \frac{\partial y}{\partial x} / \frac{y}{x}$) where y is the endogenous variable (the price), and x is the exogenous variable (the information).

91 Indeed, the analogy is quite approximate because competition has a special result (even to a greater extent than cooperativeness), namely, the strengthening of the 'figh - ing' capacity of the economic agent, including the loser (in terms of economically narrow aspect, e.g., in monetary terms) or, perhaps even more so in the case of the loser (Nietzsche's aphorism, *Was mich nicht umbringt macht mich stärker* – what does not kill you, strengthens you – although, of course, with a different purpose, fits here too and, incidentally, fits the whole evolution of life).

92 We observe here a very important aspect, namely, that we have a case diametrically opposed to the one encountered in the matter of factual falsification of the Popperian type. Whereas, in the case of falsification, the corroboration (neither validation nor confirmation) of a hypothesis does not increase the probability that the theory from which that hypothesis was extracted is true (as the refutation of the hypothesis gives a probability equal to 1 that the theory to be false); on the contrary, in the case of preference, such a corroboration increases the probability that the preference will be maintained.

93 However, this conjecture must be tested factually (either by artificial experiment or by natural experiment).

94 Here too we can, of course, have a curve of indifference, namely, a curve which could be called the 'cumulative amount of loss' $L^P_{[t,\tau]}$, where with t and τ were noted moments of time (the interval $[t,\tau]$ signifying the period in concerned) and with P noted the preference. So, $L^P_{[t,\tau]} = \sum_{i=t}^{\tau} l_i^P$ where with l noted the 'individual' loss, generated by the choice at the time i based on preference P.

95 Fitness is a notion that originated in biology but has now spread to other areas, particularly economics and sociology, to denote the degree of adaptability/adaptation of a species to its environment. Fitness is the effective reason (and sometimes the material cause) of evolution.

96 As is well known, in the field of economics, there are notable achievements in identifying the microeconomic fundamentals (or fundamentalness) of the macroeconomics (Bergh & Gowdy, 2000).

97 Cybernetic systems in which the observer is external, that is, not a subsystem of the observed system, are called first order cybernetic systems.

98 Here we can mention the famous Lotka-Volterra equations (targeting, however, only the dynamics of two populations, one of which consists of predators, and the other of prey): $\frac{dN1}{dt} = N1 \cdot (r1 - b1 \cdot N2); \frac{dN2}{dt} = N2 \cdot (-r2 + b2 \cdot N1)$, where $N1$: prey; $N2$: predator; $r1$: growth rate of $N1$, without predators; $r2$: $N2$ mortality rate, without prey; $b1$: prey mortality rate caused by predators; $b2$: the rate of predators' ability to catch prey (Hofbauer & Sigmund, 1998).

99 If the parasite-host relationship does not present any benefit (nor any harm) to the host, it is referred to in the specialty literature as a *commensalism* or *commensality* (Norgaard, 1994), and if there are advantages to the host, it is called relationship of *mutualism*. (*Nota bene*: this is because, in both cases, the parasite obviously obtains advantages from co-evolution.)

100 The concept of the *chreod* was introduced into the specialty literature by the British biologist C. H. Waddington and signifies a necessary (i.e., mandatory, in a logical sense) path or trajectory of a system. The concept of chreode is associated, by the same author, with the property of homeorhesis, meaning the return of a disturbed system to its trajectory (steady flow), just as the property of homeostasis means the return of a disturbed system to its state (steady state). In fact, the concept of homeorhesis is a generalization of the concept of homeostasis – homeostasis applies to stationary systems, while homeorhesis applies to non-stationary systems (*Nota bene*: in the biological field, homeorhesis is also called developmental canalization or robustness; in our opinion, homeorhesis could be called, in a more appropriate way with its content, *resilience of development*).

101 It could also be added that R-strategies are associated with optimality, while K-strategies are associated with sustainability.

102 Of course, the issue of hysteresis can be discussed here, which refers to the difference between the path that the system has been displaced by the disturbance and the path that returns to the previous state, but the development of the idea of hysteresis will be done in later sections of the study.

103 And from the aphoristic point of view, it falls into the category of *fluctuat nec mergitur* systems (*lat*. it shakes but does not sink).

104 It must be said that no free market is, conceptually, free because there is a set of rules (tacit or codified) that govern the market in question. In the most general sense,

any market is normed: for example, in the (fundamentalist) model of neoclassical economic theory, *homo œconomicus*, although we can accept (ideally) that no rule is imposed institutionally, there is, however, a norm which governs that model: selfishness.

105 To some extent, an automatic stabilizer works similarly to the invisible hand (in the case of coded institutional automatic stabilizers, the invisible hand works after the discretionary introduction of that stabilizer).

106 The five components represent the generic structure, but, of course, there may be others: for example, it could be an early warning component/device for disturbances (such as financial market noise) or an anti-fragility component/device of the disturbances, and so forth. In addition, resilient (and even robust) systems have redundant components compared to the five standard components.

107 From the mathematical point of view, if it could be shown that there is certain symmetry of behaviour of the reaction preference to disturbance, then using the Noether theorem (adapted from mathematics and physics to economics), it might identify laws invariance (or conservation) in matters of adaptive preferences. The identific - tion of conservation laws is fundamental in identifying, on this basis, predictors on the financial market.

108 NAIRU is the acronym for Non-Accelerating Inflation Rate of Unemployment; NAWRU is the acronym for Non-Accelerating Wage Rate of Unemployment.

109 Version of original function Taylor rule is as follows: $i_t = \pi_t + r_t^* + a_\pi\left(\pi_t - \pi_t^*\right) + a_y\left(y_t - \overline{y_t}\right)$ where i_t is the monetary policy interest rate, π_t is the current inflatio , π_t^* is infl - tion target, r_t^* is the equilibrium base interest rate, y_t is the natural logarithm of current GDP, and $\overline{y}_t$ is the natural logarithm of potential GDP. *Nota bene*: the standard proposal is like $a_\pi = a_y = 0.5$. The lags considered are between three and six quarters.

110 Stationary processes are those processes whose fundamental parameters are invariant in relation with the time (e.g., in a stationary time series, mean, variance, self-correlation is invariant in relation with the time variable).

111 It is impossible not to immediately relate to the fact that preference has also been defined as the 'ability' of the economic agent to identify the highest probability of a particular event in the distribution of events it faces. The conclusion, generated by this analogy, is that economic preference is a preference for something very similar to a natural value, that is a value that persists over time.

112 We do not discuss here that EMH has never provided a theory of the mechanism (which, certainly, evades the neoclassical economic theory paradigm of the *homo œconomicus* model) by which the available information (in any of the three efficien market cases) is captured in price instantly, completely, and without transaction costs.

113 In doing so, Samuelson wanted to replace the random walk hypothesis with that of fair game (i.e., that game in which neither players can always win or always lose). Fame, as it is known, built his EMH on random walk. In addition to the martingale (which is, mathematically, a stochastic process) that describes the fair game for the financial market, there are also sub-martingales – which target higher prices in the future – and supra-martingales – which target lower prices in the future. All, however, imply the absence of any correlation between past prices and future prices.

114 The non-coverage of the equilibrium condition by the stationarity condition is obvious considering that both the increase of the parameter of interest and its decrease can very well occur in conditions of constant mean or variance – for example, the pair of numbers (8,20) has the same average with the pair (1,27), respectively, with the pair (13,15). However, statistically, stationarity is a good proxy for equilibrium.

115 As Andrew Lo also accepts, AMH is a generalization of EMH, in the sense that, by its action, it 'pushes' the financial market towards the conditions stipulated by EMH.

116 Here is a new opportunity to emphasize the need to carefully distinguish between stochastic and random – genetic variation (mutation) is not stochastic but random (although genetic engineering or transhumanism could reduce randomness to stochastic or even deterministic).

117 There are also previous contributions to the issue of the double inheritance of human behaviour; see R. Boyd and P. J. Richerson, 1992, 'Punishment Allows the Evolution of Cooperation (or Anything Else) in Sizable Groups', *Journal of Ethology and Sociobiology*, (13), and R. Boyd and P. J. Richerson, 1985, *Culture and the Evolutionary Process*, University of Chicago Press, Chicago.

118 The theory of double inheritance is also called (a) cultural Darwinism and (b) evolutionary anthropology. It is obvious that this theory goes beyond socio-biology (see Edward O. Wilson, 1975, *Sociobiology: The New Synthesis*, Harvard University Press, Cambridge) which only sets the limits that culture can set for nature.

119 It seems that the economists do not have a theory of the economic impact on the institutional (although, conversely, they have a theory of the institutional impact on the economic – see the institutionalism, primarily its initiator, from the perspective of the new history of economics, Douglass North).

120 See, for example, the Marxist theory of society or even the Kantian theory of perpetual peace.

121 Here we have, as we have shown earlier, a memetic transmission of behaviours.

122 Kinship altruism (group selection) is common in the non-human living world (kin selection). In society (respectively in the economy) the group selection is of the non-kinship type (*Nota bene*: although the concept of clientele, especially in the political field, is still maintained in the group selection based on kinship) being based on mutually beneficial cooperation. In fact, group selection in economics is a type of mutual altruism selection (*lat*. Quid pro quo; *Engl*. tit-for-tat).

123 In the social field (including the economic field), altruism neither based on kinship nor on utilitarian interest is an interest based on a kind of cultural kinship: community based on religion, level of education, and other affinitie (e.g., the nature of attraction between women and men) – this type of selection is also known as assorted selection. As a result, the degree of affinit (and, to a lesser extent, kinship) is a predictor for assortment (i.e., for the probability of cooperation). Assortment probability is, of course, an *a priori* (initial) Bayesian probability.

124 From a conceptual point of view, as we suggested earlier, the genetic mutation (more generally, the genetic code) represents a norm (a normative framework), it is true, a natural, biological norm. Therefore, in the double selection in the economy (in the financial market), we have, in principle, only normed behaviours – the mix of genetic norms-cultural norms is another problem, which must be examined separately. Therefore, in principle, there can be three categories of norms that guide human behaviour: (a) genetic norms, (b) positive (legal) norms, and (c) theoretical norms (theories, equations, models).

125 The self-catalytic cycle (when the cyclic chain comprises more than one link) is also the content of the concept of *hypercycle* (formalized as a first order differential equation, which describes a network of reactions), introduced by Manfred Eigen, see his work from 2013, *From Simplicity to Complex Familiarity: A Treatise on Matter, Information, Life, and Thought*, Oxford University Press; and the book (together with P. Schuster), from 1979, *The Hypercycle: A Principle of Natural Self Organization*, Springer-Verlag.

126 Hormesis (from gr. *hormáein* – to set in motion) is a process (based on the correspondent property) by which the systems are immunized against disturbances exactly by accepting small doses of disturbance (below the threshold of their destabilization).

It is (along with other factors) the basis for generating the antifragility property (Taleb, 2014). A case of anti-fragility in the economy, based on hormesis, is the effect of financial leverage ($r_f = r_e + \frac{D}{OC} \cdot (r_e - r_d)$, where r_f . is the rate of financial profi - ability (of a company, or the state, as the case may be), r_e is the rate of economic profitability, D is the debt, OC is the own capital, r_d is the interest rate to the contracted debt, $\frac{D}{OC}$. is the financial leverage, and $\frac{D}{OC} \cdot (r_e - r_d)$ is the financial leverage effect.

127 In addition to this research (which will be published in two volumes), the authors will elaborate and publish a handbook titled *Autopoietic Modelling of the Financial Market: An Introduction*.

128 The name is probably deliberately constructed symmetrically with EMH (to draw attention to the fact that it is of the same paradigmatic force), because, in fact, it is not the market that adapts but the preferences (the market also has preferences, from which it is nothing more than the set of behaviours of the other agents or, equivalently, the manifestation of the other trading strategies). In fact, we do not want to be too critical of this formulation, because we ourselves will do the same when we propose the hypothesis of the autopoietic market (APMH), which is a generalization of AMH, which is, as Lo declared, in turn, a generalization of EMH.

129 The concept of *punctuated equilibrium* has been introduced in the specialty literature (with regard to biological evolution), in contrast to the gradual evolution by the evolutionary biologists (palaeontologists) Niles Eldredge and Stephen Jay Gould, in their book of 1972, *Punctuated Equilibria: An Alternative to Phyletic Gradualism*, in T. J. M. Schopf, ed., *Models in Paleobiology*, Freeman Cooper.

130 Phydimetrics is a (possible) new technique which we propose to handle the time series, considered isolated from any other time series (causally, correlationally, and conditionally). Therefore, some fundamentals of the time series involved must be found, as internal/own pace or time, internal/own cyclicity, and so forth, so, finall , a set of invariants of that time series should be identified which could then be used as bases for predictions. A sort of self-causality should be identified (phydimetrics comes from Greek: φίδι, *phidi*, which means snake, and μετρούν, *metroun*, which means to measure. Metaphorically, phydimetrics is related to the snake named Ouroboros, which eats its own tail.

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2 Mechanism of adaptive preference

Introduction

Preamble

A theory is, in essence, a hypothesis, and this is true both in the field of natural sciences[1] and in the field of social sciences, including economics. Regarding the financial market, moreover, this idea is kept in the very name of the most important theories proposed for the description, explanation, or (final ta get) prediction of the financial market –the Efficien Market Hypothesis (EMH),[2] proposed by Eugen Fama in 1965 (Fama, 1965) and in 1970 (Fama, 1970), or the Adaptive Market Hypothesis (AMH), proposed by Andrew Lo in 2004 (A. W. Lo, 2004). Even the ideas that preceded these theories and prepared them, including from a mathematical standpoint, were expressed as hypotheses or conjectures (Cardano, Bachelier, Mandelbrot, Samuelson – in chronological order).

A model – either logical or quantitative – is usually used to provide a description of how the hypothesis works, as well as to allow empirical testing of the hypothesis in question and, eventually, to generate predictions in the field. In addition to hypotheses which are of a principled, axiomatic nature, methods or techniques, or even tools, are also elaborated in knowledge. The methods are not necessarily rounded to a hypothesis (theory) but are universally usable – for example, the standard econometric analysis technique, the fractal, spectral, fractional analysis technique, and so forth. In the present study, the interest is focused on the hypothesis or theory and on the corresponding logical model of the respective hypothesis or theory.

The concepts of modelling and model

Modelling

The modelling is a rational process by which a model is obtained. The model refers to a segment of reality, previously selected on the basis of model-independent criteria, although there may be situations in which such independence cannot be maintained – for example, if a model based on Fourier series is to be developed, a linear segment of reality cannot be chosen; the same can happen

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with the choice between continuous type models and discrete type models. It should be noted that modelling involves knowledge. A segment of reality in relation to which knowledge does not already exist cannot be modelled, because the resulting model must represent that reality.[3] As we will see, the modelling is inherently characterized by cognitive 'losses', that is, the result of modelling – which is the model – is cognitively 'poorer' than the reality captured in the model.[4]

If the purpose of modelling is not to know the modelled reality, then in what consists this purpose? It consists in providing a logical and quantitative testing of the theory or hypothesis[5] that was the basis for the elaboration of the model.[6] As it is known, the philosophy of science accepts the fact that theories/hypotheses cannot be verified but only rejected or corroborated (a corroborated theory is a theory yet not rejected). Of course, modelling can lead (and this often happens) to the formulation of new theories/hypotheses that, in turn, require other modelling (models), or it is possible (in rare cases) for a modelling to suggest (to those who are prepared, as Pasteur said) a meta-modelling – this is how generalizations appear. But this possibility appears relatively rarely in the process of transition from hypothesis to model.[7] From a conceptual point of view, modelling introduces, compared to the modelled reality, a certain epistemological simplicity. By epistemological simplicity is meant the delivery, by the model, of a description of economic phenomenology as close as possible to understanding (comprehension), even if it moves away, at the level of intuition, from the real functioning.

The modelling is based on two principles: (a) the principle of *intelligibility* – the targeted reality segment[8] can be described in a 'story' (e.g., in a theory, which, conceptually, is a story) that has internal logic;[9] and (b) the principle of *causality* – the targeted reality segment can be described as a structural-functional binomial of cause-effect type. In the field of natural sciences, in which only object-object interaction is studied (e.g., in physics), the principle of causality is also known as the principle of objectivity, but in the field of social sciences (hence also economic), the principle of causality should be considered as a mix between necessity and free will (or between necessary and contingent). Besides, in this research, the principle of causality will be treated from this mixed perspective.

Limiting the discussion of modelling to the case of economics, the question arises: how does economic modelling integrate into the model two of the most important characteristics of economic phenomenology: uncertainty[10] and irrationality, respectively?[11] We present some considerations in this matter:

- uncertainty means a parameter or property associated with real systems that expresses the absence of complete information at the level of the knowing subject ('modelling' subject);
- uncertainty is specific to random systems, not stochastic systems; however, admitting the random nature of real systems creates more problems than it

solves (subjective probabilities could be, with some caution, accepted in the 'modelling' of uncertainty);
- irrationality means the impossibility to derive economic decisions based on a model of justification of the choice, under the conditions of compliance with the rules of validity of the inference. For example: the inability of the *homo œconomicus* model to do this (this model has been factually rejected for a long time and, it seems, definitively) [12]

The solution for integrating both uncertainty and irrationality in economic modelling consists of two operations of simultaneously conceptual and methodological nature: (a) reintroducing the economic subject into the economic process, which involves accepting *teleology* (purpose) in the causal structure of the economic phenomenon; and (b) waiving to carrying out of the phenomenological predictions and replacing them with scenarios for achieving the *normatively set targets* (i.e., 'a-rational').[13]

Model

As stated earlier, the model is the result (effect) of the modelling process. Conceptually, a model can belong to one of the following three classes of models:

DISCOVERY MODELS

- examine/investigate/interrogate the object of knowledge, without this representing a predetermined target of the scientific approach (here, as a rule, *serendipity* appears);
- the discovery model is *open*, that is, sensitive to any detected result (without this implying incoherence).

CORROBORATION MODELS

- examine/investigate/interrogate the object of knowledge following, in a positive way, *a predetermined target* of the scientific approach;
- the corroboration model is *closed* (relatively 'blind' or relatively insensitive to possible results that could be relevant but which do not overlap with the desired result or in its close margin).[14]

REFUTATION/REJECTION MODELS

- examine/investigate/interrogate the object of knowledge following, in a negative way, *a predetermined target* of the scientific approach;
- the refutation/rejection model is *closed* (relatively 'blind' or relatively insensitive to possible results that could be relevant but which do not overlap with the desired result or in its close margin).

From a formal (logical) point of view, a model can belong to one of the following four classes of models:

1 opaque models (*black box*): reconstitute the variation of the outputs as a function of the variation of the inputs and states:

$$y_i^k(t) = f_i^{w_i}\left(x_i^1(t), x_i^2(t), \ldots, x_i^{m_i}(t); s_i^1(t), s_i^2(t), \ldots, s_i^{n_i}(t)\right);$$ y: outputs, x: inputs, s: states

2 functional models (*of evolution*): reconstitute the variation of states as a function of the variation of inputs and outputs:

$$s_i^k(t) = h_i^{q_i}\left(x_i^1(t), x_i^2(t), \ldots, x_i^{m_i}(t); y_i^1(t), y_i^2(t), \ldots, y_i^{p_i}(t)\right)$$

3 behavioural models (*of impact*): reconstruct the variation of the inputs as a function of the variation of the outputs and of the environment:

$$x_i^k(t) = g_i^{q_i}\left(y_i^1(t), y_i^2(t), \ldots, y_i^{p_i}(t); z_i^1(t), z_i^2(t), \ldots, z_i^{d_i}(t)\right);$$ z: noise (disturbance)

4 decision-making models (*of choice*): reconstitute the variation of the inputs as a function of the variation of the output and the purpose (of the command):

$$x_i^k(t) = v_i^{q_i}\left(y_i^1(t), y_i^2(t), \ldots, y_i^{p_i}(t); e_i^1(t), e_i^2(t), \ldots, e_i^{b_i}(t)\right);$$ e: purpose (objective)

Figure 2.1 provides a synoptic image of the model classes from a formal perspective, indicating the general lines of behaviour.

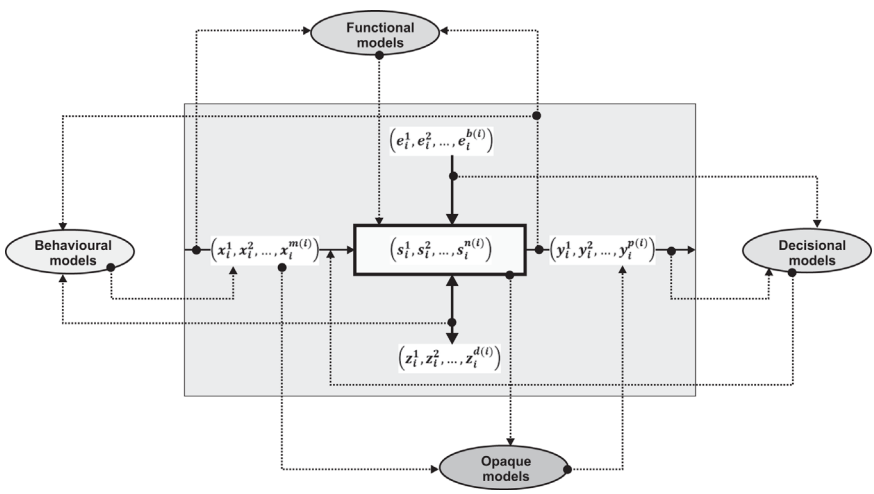

Figure 2.1 The formal behaviour of models.

Source: Authors.

The concept of logical model/logical modelling

Logical modelling, the logical model, aims at the purely conceptual aspect of modelling (of the model). It is an abstract representation of the segment of reality under consideration that does not require materialization. A common example in logical modelling is the so-called mental experiment – an experiment that uses a representation generated and operationalized exclusively at the level of consciousness. In the history of science, there are famous cases of mental experiments (in other words, of mental representations, purely logical); two examples are as follows: Einstein (with his 'journey' on a photon) and Schrödinger (with his famous cat half-alive, half-dead). In areas where factual experimentation is impossible, such as history, models are exclusively logical. Also, in the matter of the future, the realization of models that go beyond the abstract/logical aspect is particularly difficult There are writers and even musicians (Mozart is well known) who have stated that before materializing the work of art, they conceived it entirely in their minds.

Logical modelling (and the logic model) must include the following fundamental components: (a) principles/axioms, (b) the rules of inference of the theorems/lemmas from axioms, and (c) validation and control rules.

PRINCIPLES/AXIOMS

A logical model is based on a set of principles or axioms which, as the name suggests, are primitive principles (or prime), without having to be justified and even less demonstrated. They are chosen (usually invented) in a relatively arbitrary way, being suggested by the researcher's intuition, by his experience, or by the purposes of modelling (usually by a sui generis combination between the three commands).

INFERENCE RULES

Inference rules must be established to allow derivation or inference, from principles/axioms, of possible theorems and, on the basis of the theorems, consequences/lemmas. Axioms and rules of inference ensure the sufficien set for the operation of any logical model. The most used inferential rules are those specific to bivalent logic (also known as Aristotelian logic), with two values of truth: true and false, respectively. Inferential rules are usually described as syllogisms,[15] and the most common method of judgement is *modus ponens*.[16]

TEST/CONTROL RULES

Test/control rules refer to those rules meant to validate the truth that the logical model can deliver to users. They are also operationalized in the form of a syllogism, but this time it is a syllogism *modus tollens*.[17] The *modus tollens* rule is the rule on which Popperian-type falsificationism is based.

The predicates of the logical model

The concept of logical model can be described, exhaustively, by enumerating its predicates:

- it is an *artefact*, that is, it implies a purpose:
  - the goal presupposes, in turn, a cultural subject ('endowed' with consciousness);
  - there are no models in nature;
- it is an *intellectual* construction:
  - no physical way of accomplishment is required, although it is not excluded;
  - retains, from the modelled system, what is defining (does not take over accidents or short-term redundancies);
- is independently *reproducible* (the model is of public relevance). The way in which the model is constructed is not an esoteric one ('esotericism' is, however, allowed in the 'internal' phase of the research, until the public formulation of the model);
- it is a *method* of *testing hypotheses*, not a method of knowledge;
- may contain computational components/routines (may be *partially* algorithmized).

Conditions for configuring logical models

The conditions that must be met to ensure the aforementioned predicates of a logical model are the following:

- *structural isomorphism*: the model is an intellectual cut-out from reality. Regardless of the tool used for modelling, it must replicate the structure of the real cut-out;
- *causal analogy*: the model reproduces the real causality (Hume-ian condition); therefore, since we know *ex ante* causality, the model is not a method of knowledge but only a testing of a pre-existing knowledge (in fact, a hypothetical knowledge);[18]
- *functional stability*: the model can withstand repeated sessions of use, without damaging its performance. This logical condition also ensures the public character of the model;
- *epistemological simplicity*: the model is less complicated than the real modelled cut-out (e.g., a clone is not a model). This is a minimization condition like the 'minimum action principle' (or the Maupertuis principle);
- *retroversion of the result*: there are operational ways in which the results obtained in the model can be applied in the modelled reality. This is a praxiological condition, rather, but we retain it as a logical condition.

Financial market and the logical model

The necessity for a logical modelling of the financial market

Preliminaries

An economic market is a set of economic exchange relations (goods, services,[19] information, symbols[20]), based on informal rules (tacit, i.e., emerging from the exchange process itself), on formal rules, or (in most cases) on a functional mix between the two types of regulation. There are three types of economic markets, according to the predominant object of the transactions: (a) markets for economic goods and services, (b) labour services markets, and (c) financial markets.[21] In the following, we will focus only on the financial market, and even on a small segment of it, namely, the capital market (e.g., we will not address the issue of the banking system).

The financial market[22] has as object of the transaction a derivate[23] of economic goods/services (e.g., shares, bonds, indexes), goods/services that remain the sustainability support of these derivatives, but the derivative, in the operational sophistication of the contemporary financial market, becomes increasingly distant, both qualitatively and, especially, quantitatively (the monetary volume of financial derivatives is enormous in relation to the monetary volume of the initial real support)[24] from the real economic support. In fact, the so-called fina - cial instruments[25] are traded on the financial market, which are of three types (of course, with many contextual species):

- *equities* – for example, stocks, shares;
- *debts* – for example, bonds, loans;
- *derivatives* – for example, forward contracts on an asset or an index.

The necessity for a logical modelling of the financial market

As in any field of knowledge and action, we need an explanatory theory (a logical model) that captures, in a coherent 'story', the phenomenology of the financial market (as already mentioned, we will refer exclusively to the market of capital here). And just like in any field of knowledge and action, the necessity to modelling the financial market comes from the imperative of solving practical problems (or, in our case, rather, praxiological or pragmatic problems). The problem (or problems) that needs to be solved by modelling (theorizing, more generally) the financial market are as follows:

1 the problem of *direct external financing* of economic activity – financing of economic activity can be done in three main ways: (a) through internal financing (or self-financing), (b) by appealing for indirect external financing (e.g., from banks), and (c) by appealing for direct external financing (such as capital market financing);

2 the problem of *capital gain* – refers to the possibility of exploiting the opportunities that appear on the financial market as a result of forecasting errors of economic agents (e.g., those who rely on a long position, compared to those who rely on a short position), on the one hand, and as a result of the intrinsic functioning of the financial market, on the other hand (e.g., inertias – moments – in the dynamics of an asset price or, on the contrary, opposite games or contrarian strategies[26]);
3. the problem of *developing economic theory* – refers to the fact that the fina - cial market has proved unexpectedly productive and challenging regarding the economic behaviour. The most important (and disturbing, by the way) empirical results of the rational/irrational relationship in economic choice (and which have led to the recent explosive development of the so-called behavioural economy) were provided by examining the functioning of the financial market.

The possibility of logical modelling of the financial market

As shown earlier, there is a quasi-equivalence between theory/hypothesis and model. However, the 'standard' case is the one in which we have already elaborated a theory/hypothesis, and based on it, we develop a logical model. So, in principle, there is a certain difference between theory and model. This difference concerns two aspects:

The theory offers explanations; the model offers testability

An explanation is a description of a causality,[27] even if that causality is imposed axiomatically. For example, the neoclassical economic theory proposes a master explanation for explaining economic behaviour: *individual selfishness*. Instead, the *homo œconomicus* model (which is built on neoclassical economic theory) offers the possibility of organizing experiments (or the observation of natural experiments) so as to factually test predictions elaborated within the neoclassical economic theory. The model does not and cannot contain more knowledge than the theory on which it was elaborated; instead it offers ways to test[28] it. There is, of course, a co-evolution at the level of the theory-model pair: the model can contribute to the improvement of the theory, precisely by rejecting predictions that thus refute some components of the theory, while the theory, as it improves, leads to variations in the related model. A well-known example can be found even within the neoclassical economic theory: when, by operationalizing the *homo œconomicus* model, certain anomalies were discovered regarding the absence of individual hyper-rationality, the theory underwent a change, namely, the reduction of hyper-rationality to limited rationality (*bounded rationality*, a concept proposed by the Nobel laureate in Economics, Herbert Simon, in 1955), and this led to the introduction of the new type of rationality in the *homo œconomicus* model.[29]

The theory and the model are not bijective correlated

A theory can have multiple operational models for testing, with each model adhering to the axioms of the theory in question. Rarely, but possibly, some models have referential in several theories. The last possibility refers to the case where the model is intended to test a case of multi-disciplinarity or, more interestingly, a case of inter-disciplinarity. Also, the emergence of boundary disciplines requires models that can factually test extracted theorems/lemmas regarding that 'boundary' on which the theory is built.

Therefore, the possibility of modelling the logical model of the financial market lies precisely in the fact that this area of economic action is (can be) the subject of theorizing. The financial market is ta geted by two levels of theorizing:

- a *general* level of theorizing: the financi l market is a structural component of the economic system, so the theory that describes economic causality describes, *eo ipso*, the causality of the financial market. The theory of economic phenomenology includes all three categories of economic action: real, financial, and nominal (the financial market falling into the category of nominal economy),[30] so the causality of the economic system will also include the causality of the nominal component. Economic behaviour is coherent with the three components – an individual cannot have (too) different criteria of behaviour in the real economy than in the nominal economy. An example of general theorizing: neoclassical economic theory;
- a *special* level of theorizing: in addition to the general level, there is also a special level of theorizing, that is, a theorizing with a higher degree of analyticity regarding the financial market in what it is own, specific. Special theorizing is, of course, consistent[31] with general theorizing but, somehow, represents a customization or application of general theorizing to the case of the financial market.

In accordance with the object of the present study, in the following section, we offer a brief review of two logical models regarding the financial market: (a) the EMH logical model and (b) the AMH logic model.

Remarkable logical models of the financial market in the specialty literature

Despite some varieties (which express operational adjustments rather than principal changes), the financial market is logically modelled, as mentioned earlier, by two[32] important models, each based on a generating theory. The first model is that of (financia) market effici cy: the *Efficient Market Hypothesis* (EMH), and the second model is that of (financial) market adaptivity: the *Adaptive Market Hypothesis* (AMH).[33] In this section we will present only the general lines of the two models/theories, because the other two chapters of the study are intended for the detailed development of some structural aspects of the second model – the

model of interest for the research as a whole. We will also not analyse separately another (possible) model of the financial market (more generally, of economic behaviour), for example the *Behavioural Market Hypothesis* (BMH), for two reasons: (a) this 'model' does not have a cohesive theory (one of the substantive objections brought to behavioural economics by the author and AMH followers) and (b) its basic coordinates are taken over (and integrated) by AMH which, as we will see, explicitly states that it is trying to combine EMH and BMH in a functional way.

The Efficient Market Hypothesis

OVERVIEW

EMH is a model of the financial market attributed to Eugen Fama[34] (who also received the Nobel Prize in Economics for this, in the good tradition of the Nobel Committee to encourage the expansion of the neoclassical model in economic research).[35] In essence, EMH says that prices in the financial market instantly encompass the information available on the market, which means that future prices are necessarily subject to random flo , so they are unpredictable.[36] This also means that no analysis effort can lead to price predictability,[37] so no gain can be obtained in an efficien market.[38] In fact, there are not one but three meanings of the concept of efficient (financial) mar [39] (Leković, 2018), all endorsed by Fama itself:

- *first meaning* of the efficien market: prices fully reflect the available information;
- *second meaning* of the efficien market: prices reflect all available information only if the transaction costs of access to information are zero, that is, prices reflect only the information for the procurement of which the marginal utility is equal to the marginal cost;
- *third meaning* of the efficien market: the introduction of over-reaction and under-reaction,[40] also based on the integration of available information in the current price. Behaviours of over-reaction and under-reaction to new information, respectively, are associated with the concept of moment in the dynamics of the time series in question, but it seems that exploiting patterns related to *momentumness*[41] is too expensive (Malkiel, 2003).

EMH BASIC ELEMENTS

On the conceptual line

- it is a model that is based on (has in the background) *neoclassical economic theory*, so it is a logical (inferential) consequence from the theoretical model *homo œconomicus*; this means that all the axioms and conditionings of the *homo œconomicus* model are also found (and are verified by) in EMH. Like the *homo œconomicus* model, EMH presents itself as an ideal model (the so-called frictionless model);[42]

- along these lines, the principles on which EMH is based can be seen:
  - the risk-return relationship is linear;
  - the risk-return relationship is stable over time and in any situation;
  - the parameters can be estimated;
  - all investors have reasonable expectations;
  - yields are stationary (their conditional distribution does not change over time);
  - markets are efficient (in the sense defined by Fama
- a model aimed at the *informational* efficienc of the (financial) market. This is an extremely important element, and the fact that EMH focuses on the informational aspect is an 'Achilles' heel' (along with the second 'heel' – considering the *homo œconomicus* model as a theoretical background) of this paradigm. This aspect will be one of the theoretical pillars of the logical model that this study will propose; therefore, it will not be further developed at this point;[43]
- EMH does *not* provide a *mechanism for integrating* (capturing) historical and current information into the variation of the price (or yield) of the efficien market[44] (Lo, 2004). Although this integration represents the fundamental axiom (founding principle) of the paradigm, it is not covered by an appropriate theory to explain (thus to provide a causal description of) the price variation due to the information available on the market but is, simply decreed. Of course, an axiom is 'decreed' by definition, but it must still be explained to the causal level.[45]

On the methodological line

- EMH is based on the integration assumption (axiom) with necessity of the impact of past (and present) information;[46]
- the *random walk* is used as an analysis benchmark (including the 'detection' of anomalies referred to EMH), or the Wiener-type stochastic process or (partially) Samuelson's martingale;
- there is a methodological difference (of fundamental operational approach) between the result of Samuelson and that of Fama: in the case of Samuelson, it is about efficienc as a state, that is, we have an axiomatic efficienc of result type (or final state type), efficienc which is introduced through martingale,[47] while in the case of Fama, efficienc is treated as a process, that is, in this second case, we are dealing with an empirical efficienc [48]
- the methodology suggested by EMH (a statistical methodology par excellence) fails to reveal at least three of the characteristics of price dynamics under the impact of past and current information: variability, discontinuity, and concentration of price variation. In this sense, an analysis and prediction technique has been developed (useful in designing/choosing trading strategies on the financial market), inspired by Mandelbrot's work: fractal analysis.[49]

On the formalization[50] *line*

- *fair game model* (martingale)
  - given the historical price series: $\Phi_t = \{p_1, p_2, \ldots, p_t\}$;
  - then $E(p_{t+1} / \Phi_t) = p_t$, where E is the expected value – or mathematical expectation;
  - be r_{t+1} the yield of the asset; then $E(p_{t+1} / \Phi_t) = (1 + E(r_{t+1} / \Phi_t)) \cdot p_t$;
  - if $p_{t+1} > p_t$ we have a supra-martingale, if $p_{t+1} < p_t$ we have a sub-martingale;
  - be x_{t+1} price deviation (market deviation): $x_{t+1} = p_{t+1} - E(\tilde{p}_{t+1} / \Phi_t)$, where $\tilde{p}$ is observed (effective) price;
  - then $E(\tilde{x}_{t+1} / \Phi_t) = 0$.
- *random walk model*
  - the Brownian distribution is independent and identical;
  - the probability distribution is the same (information on one variable does not influence another variable);
  - let the density function of the distribution: f;
  - then $f(r_{t+1} / \Phi_t) = f(r_{t+1})$, that is, the marginal conditioned distribution of the probabilities is identical to the unconditioned distribution;
  - so $E(r_{t+1} / \Phi_t) = E(r_{t+1})$.

  Nota bene: Samuelson introduces the Brownian geometric distribution: $p_t = p_0 \cdot e^{\alpha t}$.
- *short formalization of the EMH*
  - price variation is a random process in which the price is conditioned by new information;
  - $p_{t+1} = \mathbb{E}(\tilde{p}_{t+1} / \Omega_t) + \varepsilon_{t+1}$, where $\mathbb{E}(\cdot)$ is the operator of expected value, $\tilde{p}$. is the stochastic price variable, Ω is the public information set, and ε is a random error variable (meaning that no systematic gain can be obtained from the market by exploiting price variation);

  Nota bene: in an informationally efficien market, the price moves completely randomly and unpredictably because all agents instantly incorporate new information into the price.

On the testability line

- despite the impossibility of empirical testing[51] (which few of the tireless article writers have reflected on), empirical testing has of course been done (and has been accepted in pretentious publications, based on the widely held fetish for quantitative and, especially, statistical models). The impossibility

of empirical testing of EMH has been argued as early as Samuelson[52] (who pointed out, moreover, that establishing price unpredictability does not mean a positive result of testing market informational efficiency [53] Fama himself, in 1976, accepted the impossibility of empirical testing of EMH, in the paper *Foundations of Finance*, published by Basic Books (Alajbeg et al., 2012), and in 1998, the same Fama shows that asset prices do not follow a random walk, and their variance is not predictable (Svensson & Soteriou, 2017);

- the most widely used empirical tests (when, however, testing is attempted) on EMH (Leković, 2018) are as follows:[54]
  - *correlation/auto-correlation tests*: existence of linear correlation between past and current yield: here the equation can be used: $r_t = a + b \cdot r_{t-1-T} + e_t$, where r_t: yield at time t; T: number of intervals (lags) between current and past yield; a: autonomous (expected) yield (without the influence of past yield); b: linear correlation coefficien between current and past yield at time $t-1-T$; e_t: random residual variable (*white noise*[55]);
  - *run tests*: tests in which price increases, or price decreases, or stationary prices are recorded over a certain duration (run). Few runs mean positive correlation, and many runs mean negative correlation;[56]
  - *filter rule*: which recommends buying when the price rises more than *x*% from the lowest historical price and not selling until the price falls more than *x*% from the highest historical price;
  - *moving average rule*: the ratio of the short-term average to the long-term average determines the decision: if the short-term average is higher than the long-term average, buy; if the opposite, sell;
  - *trading range rule*: if the price reaches its maximum level, it should be sold, but if it continues to rise, it should be bought (it means that the maximum is not correctly estimated); the opposite happens if the price reaches its minimum level;
  - *relative power test*: $PR_{jt} = \frac{P_{jt}}{\overline{P}_{jt}}$, where PR_{jt}: the relative power of asset j at time t; P_{jt}: the price of asset j at time t; $\overline{P}_{jt}$: the average price of asset j for a given period. Sets of securities are designed, and based on the relative strength, trading decisions are made;
- distinction between *value stocks and growth stocks*: value stocks have been found to yield higher returns than growth stocks:[57] value stocks have a low price/earnings ratio, while growth stocks have a high price/earnings ratio.

It should be noted that many of the 'convincing' results of empirical tests (both for corroboration and refutation of EMH) are subject to the so-called Pearl Harbour effect, stated by Savage and Danziger (2009), which can be formulated as follows: *post-diction becomes intelligible*. This means that we cannot test on the basis of the past because, knowing the facts, they are additional information that

did not exist for predictions (which were formulated before we knew the facts that happened subsequently).[58] In any case, there are two crucial elements that are missing from the EMH and, by this absence, compromise the possibility of empirical testing:

1 investor preferences are missing;
2 information structure is missing (Lo, 2004b).[59]

There are a number of characteristics of financial market functioning that should be studied much more carefully by efficient market advocates

- volume – trading is not small and numerous; one can trade a large volume;
- volatility – price deviation from value is very common;
- dividends – dividend taxation is only relevant if there are taxes;
- risk premium – return earned over and above the risk-free return as compensation for risk-taking;
- predictability (Thaler, 1999).

EMH ISSUES

The first, and most important, problem with the EMH is, of course, its *scientific character*. Not being empirically testable, EMH is not scientific. That is not to say that, randomly, the hypothesis cannot give predictions that are corroborated, but it cannot do so (always) systematically, and, more importantly, it cannot do so predictably.[60] The consequence of this problem is that financial market investment strategies cannot be based on this model because they have to be applied under 'frictional' conditions.

The second problem concerns the so-called Grossman-Stiglitz (GS) paradox (Grossman & Stiglitz, 1980). Starting from the concept of an efficien market, the two economists show that in this case (i.e., where no gain can be obtained above the cost associated with risk, i.e., the market cannot be 'beaten'), nobody has any (economic) interest in trading, so the market disappears.[61] For the market to work, there must, somehow, be opportunities that (at least) some agents can exploit and thus 'beat' the market.[62] But then the market can no longer be efficient In this reasoning lies the GS paradox.[63] The GS paradox is also known as the efficien market implosion paradox (Alajbeg et al., 2012). However, it seems that increasing the number of economic agents that follow winning strategies, either by reason or by contagion, that is, exploit market opportunities, at marginal equality of cost and yield, does not lead to the efficien market as this paradox[64] demands (Litvinova & Ou-Yang, 2003).

The *third* problem of EMH concerns the so-called *anomalies* of the functioning of the (real) financial market in relation to the 'predictions' made by EMH. This problem is therefore empirical in nature. Many such anomalies[65] have been observed and catalogued, such as (a) price/earnings effect, (b) size effect (small firm effect), (c) liquidity effect, (d) ignored firm effect, (e) January effect

(Milošević & Milenković, 2017), (f) Monday effect, (g) end of day effect, (h) holiday effect, (i) intra-month effect, (j) month bounce effect, and (k) book to market effect. From a scientific point of view, anomalies are of the most importance because, as Thomas Kuhn (2012) suggests, a certain accumulation of anomalies must lead to a paradigm shift – more precisely, to the abandonment of the current paradigm and its replacement by a new paradigm, incommensurable with the previous one.[66] The problem, however, is that of the scientifici y of establishing these anomalies, given the non-testability (hence, non-falsifiabi ity) of the EMH. For example, anomalies disappear by the mere fact that they exist (see the GS paradox), because investors (so-called arbitrageurs, i.e., rational investors[67]) will exhaust the anomaly, or many anomalies arise as a result of data manipulation (either from incompetence or from self-interest), and other anomalies are reported just to combat EMH (Malkiel, 2003).

Adaptive Market Hypothesis

OVERVIEW

The necessity and possibility of applying evolutionary principles to the functioning of the markets were suggested by Farmer and Lo (Farmer & Lo, 1999) and then by Farmer (2002). AMH was proposed by Andrew Lo in his 2004 paper, *The Adaptive Markets Hypothesis: Market Efficiency from an Evolutionary Perspective*, a concept taken up more analytically in 2017 and again in 2019 in his larger paper, *Adaptive Markets: Financial Evolution at the Speed of Thought*. The adaptive market concept was 'ripe' for the general trend in economic research to move away from the physicalist model[68] (so enthusiastically introduced by Samuelson, inspired, incidentally, by his mentor Gibbs) and towards the biological model, much more appropriate to the nature of the human individual – who is the *de jure* and *de facto* creator of the economic phenomenon, process, and event. Against the background, therefore, the emergence of evolutionism research (including its more abstract species – institutionalism, initiated by Douglass North), into the financial market (in fact, the economic market in general), from a biologist's perspective, was also boosted by the results obtained by the application to economics of behaviourism[69] (which emerged in psychology), particularly by researchers who came from psychology itself, such as Daniel Kahneman and Amos Tversky, and by economists who turned to cognitive and behavioural psychology, such as Richard Thaler.[70] The behaviourist approach to economics, particularly the processes of choice (decision), including and especially in the financial market, was decisive in weakening the appeal of the praxeological paradigm of the EMH, because it undermined its very theoretical basis: the *homo œconomicus* model, drawn from the axioms of neoclassical economic theory.

The starting point in setting up AMH is human nature itself.[71] Human nature is the result of biological evolution (decisively dominant for more than 300 000 years,[72] until the invention of agriculture some 10 000 to 12 000 years ago), evolution which is produced by natural selection.[73] The fundamental criterion

for the behaviour of the individual in its natural 'version' was survival, so the choice (decision) was dictated by three perspectives that combined to generate the behaviour that ensured the survival of the species: (a) *reason* – examining the situation from a logical perspective; b) *experience* – examining the situation from the perspective of previous similar or analogous cases; c) *emotion* – particularly fear.

These three perspectives (but especially the emotional perspective) are so deeply rooted in the psychological (and therefore also behavioural) structure of the individual that, from an evolutionary point of view, it has lagged behind social, economic, and institutional innovations that have gone (and are going) at a speed incomparably faster than the biological evolution of the individual. This in fact makes the individual's behaviour in the economic market (specificall , the financial market) under the aegis of his biological nature provided by slow natural evolution and not under that of sophisticated rationality models generated by abstract unhistorical thinking. In other words, economic choice is made under emotion (or at least, *also* under emotion) rather than exclusively under rational command.[74]

This idea is also implicit in the foundations of behavioural economics (or rather behavioural psychology applied to economics), particularly in terms of the assessment of risk and uncertainty in making a decision[75] (i.e., making a choice).[76] In light of recent decades of research, economic behaviour even seems irrational in the absence of emotion, with fear being seen as the model of rational behaviour in terms of survival. This type of behaviour is based on what is known as the heuristics of representativeness,[77] which refers both to symbols and to what is known as the *crowd effect* (about the *crowd wisdom*[78] in influencing individual choice or about the *crowd madness* in this choice).[79]

AMH BASIC ELEMENTS

On conceptual line

AMH is based (has as its background) on *biology*.[80] This means that choice and the entire economic behaviour of the individual, particularly financial market behaviour, take place within the trinomial of *reason-experience-emotion* (let's call it the $RE^{(1)}E^{(2)}$ paradigm), as opposed to the EMH case where only the first component (R)[81] was considered (or was overwhelmingly) dominant. Logically, reason and emotion[82] are clearly distinct: while reason is sequential, emotion proceeds non-sequentially.[83] There are three main components of emotion: (a) fear, (b) pain, and (c) pleasure and greed that condition (at least, if not cause) choices.[84] In this context, Lo expresses the essence of the adaptive market idea – on which AMH is built – as follows: if we want to understand current behaviour, we need to understand past environments and the selective pressures that gave rise to that behaviour over time and across generations of trial and error. This idea is the essence of the adaptive markets hypothesis.[85] It is worth noting that AMH considers, alongside biology, the socio-biology of Edward Wilson. AMH also accepts some significant influences from economics (in particular from Schumpeter – creative

destruction[86] – from Hodgson, and from Nelson and Winter) or from evolutionary game theory (*cellular automata theory*) (Posenato, 2018).

If EMH was aiming at informational efficienc of (financial) market, AMH is aiming at *behavioural market efficiency*. Although it seems strange that AMH – as opposed to EMH[87] – should have a market efficienc concept in mind, from a scientific point of view, market efficienc is the only valid benchmark. Indeed, such a benchmark can only be of an equilibrium nature,[88] and the concept of efficienc is a kind of equilibrium (as already mentioned, an efficien market in the Fama sense is a market with maximum entropy, i.e., having the highest probability of emerging, which, in other words, expresses a state of stable equilibrium). Of course, a concept of *behavioural efficiency* must be rigorously defined, and, in addition, it must be associated with testability (i.e., empirical falsifiability) criteria/benchmarks, but such an approach has not yet been considered in the literature.

AMH *combines* or tries to combine *behaviourism* with EMH (and thus implicitly with *homo œconomicus*), at least in intention. In our view (for whatever reason Lo does not concede to say clearly that AMH and EMH are theoretically/conceptually 'immiscible')[89], this is not a combination at all but a generalization of EMH.[90] Indeed, like, say, Einsteinian theory of gravity, which integrates Newtonian theory of gravity as a particular case, AMH integrates EMH as a particular case (i.e., as the case where, in the trinomial $RE^{(1)}E^{(2)}$, $E^{(1)}$ and $E^{(2)}$ vanish). This is also possible because, although it has provided many new results on the psychological (and evolutionary) basis of human behaviour (of economic choice), behaviourism has not (yet) succeeded in constructing its own theory of behaviour. Behaviourism is increasingly associated with (or even grounded in) neuroscience: for example, it seems that fear is 'localized', in the brain, in the amygdala[91] which physiologically connects perception with fear (of course, the same ancestral fear that comes to us from our common ancestors with animals and that has helped us survive rather than optimize)[92]. It is possible that fear is, in fact, the true model of rationality as it relates to the contemporary individual (but, of course, that involves credible empirical tests to be designed within the AMH model).

Economic behaviour is seen, in the case of AMH, as a *behaviour subject to evolution*,[93] more precisely, co-evolution of 'economic behaviour – financial market';[94] the mutation would be the emergence of a novelty in the behaviour,[95] that is, in the trading strategy, and the selection (exerted by the environment) would translate into the rate of gain or loss (or the win/loss report) with which the choice in question is made: a strategy that performs unfavourably will be abandoned (or modified), and one that performs favourably will be replicated (note, here, the action of $E^{(1)}$ in the behavioural trinomial proposed earlier). What Theodosius Dobzhansky said about biology, that nothing in biology makes sense except in the light of evolution, probably applies to economics as well.[96] In this context, economic preferences are neither innate nor stationary (invariant); they are acquired through interaction with the environment (in this case, the financial market)[97] (Lo, 2004). Thus, these preferences can be of two types: (a) *well-adaptive preferences*

and (b) *negative adaptive preferences*.[98] Moreover, Lo considers that, among the three P's of total risk management, preference is the most fundamental but least understood concept in financial market theories (Lo, 2004) [99]

AMH is based on five principles (these principles were advanced by Lo himself, in the aforementioned 2019 paper):

- we humans are the result of biological evolution (neither completely rational nor completely irrational);
- our behaviour is heuristic and suboptimal and learns from experience;
- we are culturally evolving, linked to biological evolution;
- the dynamics of financial markets are the result of our behaviour in financial markets;
- survival is the ultimate criterion of economic behaviour and therefore also of financial market behaviou .

On methodological line

Economic behaviour (choice behaviour) is seen as a co-evolutionary outcome between the economic individual (*Nota bene*: of course, not in the sense of the *homo œconomicus* model, but in the sense, so to speak, of a *homo biologicus* model). We must expect that this eventual *homo biologicus* model[100] can integrate, in its own evolution, aspects of co-evolution or co-adaptation, as the case may be, with the environment (in this case, with the financial market; *Nota bene*: because Lo considers the environment and the financial market to be equivalent; we will reject this equivalence in what follows).

The AMH does not develop (rather, it has not so far developed) clear and proper methodological directions for modelling adaptive market behaviour (*Nota bene*: in order for the proposed model to 'rhyme' with the EMH, Lo proposed the acronym AMH which seems to refer only to market adaptability – in fact, as in the case of the EMH, it is an individual/behaviour/market relationship. In Chapter 3, we make a proposal in this regard).

AMH accepts that individuals (economic agents) do not pursue optimality, as required by rational expectations theory, but *satisciency*. Therefore, from a methodological point of view, the AMH model will have to describe this *satisciency*.[101]

AMH rejects rationality (at least the exclusivity of rationality) in economic choice and proposes, instead, *rationalization* as a cognitive 'device'. The individual is thus not a machine for reasoning but rather a machine for rationalizing, in the sense of a machine for justifying (and justification means, of course, the elaboration of a credible narrative for one's own consciousness). As mentioned earlier, rationalization is always *post factum*, while rationality is always *ante factum*.

AMH accepts that learning (co-adaptation, co-evolution) in the binomial 'economic behaviour – (financial) market' is conditioned by emotion, in any of the three forms mentioned earlier.[102]

AMH 'favours' idiosyncratic risk over systemic risk. This idea, which is particularly important from a methodological (and, of course, instrumental) point

of view, will have to be developed and formalized, including from a quantitative point of view, in order to allow for factual testing.

On the formalization line

Formal modelling of the AMH *is not completed*. Attempts following the introduction of the adaptive market concept and, implicitly, the introduction of the biological/evolutionary model into economic behaviour have been limited to identifying and examining the (fundamental) differences that exist between AMH and EMH, but, while EMH has such formal modelling, AMH is still in the process of building it. Of course, in biology or biochemistry, there are already formal models (including quantitative models) that could be sources of inspiration in this direction,[103] but, for the time being, notable results in this direction are still awaited.

A crucial element in the formalization of AMH must be, given the specificity of this model, that AMH does not pursue *first best* (as EMH does, of course) but *second best*; the chosen solution must not be better than any conceivable solution (resulting, e.g., from a pure rationality model) but must be better than the accessible solutions.[104] In other words, all assumptions about *homo œconomicus* must be adjusted to the real man.

Another fundamental element, from a formal point of view, is that, in the normative framework[105] provided by the AMH, economic behaviour (economic choice behaviour) is affected by *path dependence*[106] (see, component $E^{(1)}$ of the behavioural trinomial we proposed, earlier, formally for the AMH).

Also, from a formal point of view, the *unrealistic assumptions* of the EMH – the instantaneous character of the integration of information into the price, the absence of transaction costs in the search for information or in the assumption of risks,[107] and so forth – are eliminated.

On the testability line

Unlike EMH, AMH is a testable model, in the sense that its 'axioms' are much closer to the actual behaviour of the individual and can therefore be projected into artificial or natural experiments, as appropriate. In fact, many suggestions for testing this model come directly from behaviourist research. Even if the latter research is not designed from an evolutionary perspective,[108] it accepts both the emotional component of economic choice $E^{(2)}$ and the experience component $E^{(1)}$.

AMH testability is about showing (factually – i.e., through the Popperian prediction/description mechanism) that economic behaviours, as expressed by the choice of trading strategies, vary in relation to the market's reaction to those strategies, and in addition, the $RE^{(1)}E^{(2)}$ trinomial works. Also, another way of testing should concern how the financial market selects[109] behaviours (not biological individuals, as genetic selection does).

Through the way it was constructed, the AMH appears to provide a predictive framework for behavioural deviations from the EMH. Behavioural deviations appear to follow a 'logic' designed to achieve, based on experience, the probability meeting.[110]

Whereas, in the case of EMH, market efficienc results from the non-existence (or disappearance) of opportunities to 'beat' the market, that is, to obtain returns above the market average through simple informational arbitrage, in the case of AMH market 'efficienc is provided by adaptation.[111]

AMH can act as a predictor more than EMH can. Consequently, behaviour based on AMH must take into account not simply prudentiality (e.g., fear)[112] but also macro-prudentiality. Properly understood and applied, AMH can turn uncertainty into risk, which is a gain from both a predictability and a testability perspective.

Adaptivity can be tested by three methods: (a) *automatic variance report*, based on the variance report test and non-parametric automatic portmanteau test to assess whether there is linear independence over time (autocorrelation); (b) *generalized spectral test*, which is used to test non-linear independence over time; and (c) *dummy variables* used for economic bubbles, stock market crashes, and economic or political crisis (Svensson & Soteriou, 2017).

OTHER CHARACTERISTICS OF AMH

Alongside the basic elements of the AMH, a number of collateral features (but which have their importance in the overall design of this model) are the following:

- irrationality from an EMH perspective is interpreted as reactive rationality to environmental change;
- different degrees of market efficienc are associated with different environmental characteristics;[113]
- AMH's critique of EMH is based on (a) behavioural finance, (b) information asymmetry (GS),[114] and (c) black noise;[115]
- the innovative aspect of AMH: decisions that deviate from the optimal are not considered irrational but are given a rationality dictated by a criterion other than optimality, namely, survival;
- actual behaviour is based on habit[116] (pattern of behaviour acquired in the past);
- the adaptation of behaviour to the environment (to the financial market, according to Lo) occurs heuristically, not on the basis of any pattern of rationality (Lo, 2005);[117]
- being based on evolution, AMH can be deductive (including predictability), but for this it needs to develop a coherent and consistent theory – the way to do this is, of course, to find predictors, that is, invariances;
- the backbone of the AMH is the cyclical nature of market efficien [118] as well as the episodic nature of market efficienc between mature and emerging markets (*Nota bene*: cyclicality can be examined through non-linear independence tests);[119]
- AMH has a number of practical implications (Lo, 2019) – in fact, correctly, they are praxeological implications or at best pragmatic implications: (a) the risk-return relationship is not stable over time (the risk premium is also

time-varying because preferences are shaped by the environment); (b) from time to time, market arbitrage opportunities arise (see here also the GS paradox); (c) the effectiveness of investment strategies varies over time (e.g., risk arbitrage); (d) the key to survival is innovation (in the sense of financial innovation); and (e) survival is the only goal that matters;

- AMH is not without its problems nor is EMH, as shown earlier. AMH's most important (and urgently needed) problem is that it has no theory of how inefficiency arises in the financial market. Thus, the idea of behavioural selection by the environment does not take the discussion much further than the 'noise-sophistication' relationship that EMH also addresses. Although AMH criticizes behaviourism (behavioural economics) for not offering a theory to explain anomalies or so-called economic choice irrationalities, in turn, AMH does not (yet) offer such a theory eithe .[120]

Preliminaries to a logical model of adaptive preference

Adaptive preference and adaptive market

By definition, the term *adaptive* implies two 'parties', one of which adapts (*the adaptant*) and one to which the adaptant adapts (*the adaptar*).[121] The relationship between the adaptant and the adaptar is called *adaptation*. Adaptation is a process that has as its '*outcome*'[122] the new states of the two components of the pair.

In the concrete case discussed here, we will consider one party as the economic agent – that is, the one who chooses a trading strategy – and the other party as the environment in which the trading strategy operates, that is, the financial market.[123] The issue of the mutual 'substitutability'[124] of the two parties (i.e., the transition from adaptant to adaptar and vice versa – a phenomenon that also occurs in the biological world) will be ignored, for the moment, but we will return to it shortly.

AMH is a model (a hypothesis) that refers to the adaptive financial market, that is, the situation in which the trading strategies of economic agents try to 'beat' the market, and the market in turn adapts to this 'attack' (what exactly this adaptation means will, of course, have to be clarified in the most rigorous way). What is of interest in the present study, however, is not exactly what AMH in general is interested in – as we have said several times, AMH, with its (at least stated) vocation to represent an evolutionary model of the financial market, is interested in the following issue: *how exactly the best performing strategy (not necessarily, of course, the optimal strategy but a second-best strategy) is selected, in a process that can be called (somewhat inaccurately) 'natural selection', from among the available and affordable strategies on a given financial market variable*, e.g., the price of an asset. As we have already shown, AMH tries to achieve, mirroring natural biological selection, a process of selection not of physical individuals but of behavioural individuals, so to speak. In other words, AMH attempts to achieve a selection of behaviours, whose proxy is the trading strategy on the financial market, so it can be said that AMH is (is intended to be) a model of evolution (mutation and cumulative selection)[125] of trading strategies. This selection is made

by the market, through the rewards/penalties applied to the various strategies used (rewards or penalties, e.g., reflected in the level of returns achieved).

Instead, the scientific interest of the present study needs to be formulated diffe - ently, namely, *how preference, embedded in the chosen trading strategy, changes under the impact of selection operated on the financial market*.

In our view, a trading strategy is chosen at the intersection of two choice filters:

1 a filter represented by the three P's: price, probability, preference[126] (A. W. Lo, 1999), noted here with $P^{(1)}P^{(2)}P^{(3)}$ – we will call this filter a *nominal filter* (N-filter);
2 a filter represented by the trinomial (proposed by us earlier): reason-experience-emotion, noted here with $RE^{(1)}E^{(2)}$ – we will call this filter a *modal filter* (M-filter).

On the basis of the two filters, we will try to distinguish between adaptant and adaptar, considering the fact that the two parties are relative to each other, that is, they can substitute each other's roles and functions. Let us resume the formal description of an adaptation process (see notations in Chapter 1).

$$\mathcal{A}_{\tau}^{(0)} = \mathcal{A}\left(a_t^{(0)}, A_{t-1}^{(0)}\right)$$

Where the adaptant was noted with a and the adaptar was noted with A (the *adaptation process* was noted with $\mathcal{A}$), and the *ecological system* in which the adaptation process occurs was noted with $\mathcal{A}(a, A)$: at time t, the adaptation event (0) occurs, which consists in adaptation of the adaptant a to the adaptar A from the immediately preceding time $(t-1)$.

In general, the process of choosing (or selecting) the trading strategy (TS) proceeds as in Figure 2.2.

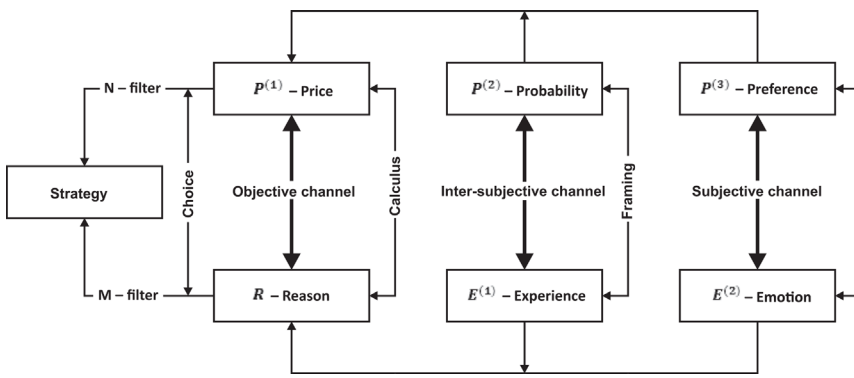

Figure 2.2 Logical description of the process of choosing the trading strategy.

Source: Authors.

The following conclusions can be retained for the benefit of further reasoning:

- the process of choosing a trading strategy is a four degrees of freedom process,[127] $PC^{(1)}C^{(2)}S$ (propensity-contextualization-calculation-choice/selection);
- each of the four components of the choice process is generated by the communication relationship between the two filters: the *nominal filter* (N-filter) and the *modal filter* (M-filter):
  - (*P*) *propensity* refers to the tendency/inclination of the agent's behaviour towards a particular choice, being generated by the interplay between emotion and preference,[128] through the subjective channel, which links the two filters; propensity is represented by the logical pair $\left(E^{(2)}P^{(3)}\right)$;
  - ($C^{(1)}$) *contextualization* refers to the framing of the agent's behaviour in the past, when, as a result of other choices, it has acquired experience and 'archived' a set of probabilities of achieving its targets;[129] both the experience and the acquisition of a set of frequential probabilities are generated by the agent's interaction with the environment (i.e., with the financial market, i.e., with other agents, thus on an inter-subjective channel),[130] which links the two filters; contextualization is represented by the logical pair $\left(E^{(1)}P^{(2)}\right)$;
  - ($C^{(2)}$) *calculation* refers to the rational assessment of the expected (or, as the case may be, predicted) price.[131] The calculation is carried out through the objective channel of interaction between the two filters of the choice process; the calculation is represented by the logical pair $\left(RP^{(1)}\right)$;
  - (S) *choice/selection* refers to the selection, from the portfolio of trading strategies available to the agent (i.e., accessible), of that strategy that resulted from the calculation.
- so, any choice starts from the idiosyncratic component (subjectively managed) and reaches the rational component (objectively managed).

The next question to be addressed can be formulated as follows: how to achieve the adaptation process following the choice process? In other words, what are the dynamics of the choice process $PC^{(1)}C^{(2)}S$, as a result (effect) of the circular interaction between agent (trading strategy) and environment? The following sections will make their own contribution to formulating an adequate answer. Before taking the next steps, we will state two interesting ideas about the (abstract) concept of adaptation, ideas that are found in Loewenstein and Ubel (2008):

- adaptation consists of actions, processes, and mechanisms that reduce the effects of repeated stimuli in the environment (in our case, the financial market);

- adaptation occurs when the response decreases or remains constant even though the stimulus in the environment increases.

On the basis of the previous two ideas about the adaptation process, one could ask (with great potential in modelling – at least logically – of adaptive preference in financial markets) whether there is an adaptation of adaptation, over time, that is, an adaptation of order 2.[132]

Information and behaviour

As shown here, EMH provides an informational view of (financial) market efficiency, while AMH attempts to move beyond information and towards a behavioural view of market efficien . It is easy to see that both theoretical models of financial market functioning have the concept of efficienc as a benchmark or condition for assessing the state of the market. Efficienc is seen, in both views, as a state of equilibrium – neither an opportunity to 'beat' the market on the basis of information in the case of EMH nor an opportunity to 'beat' the market on the basis of behaviours/strategies in the case of AMH. Given the different views of the two established models, in the following section, we provide a brief discussion of the relationship between information and behaviour in achieving financial market efficiency/equilibrium Information already has an impressive status among the concepts with which science (and even policy) operates:

- information has acquired enormous 'prestige' as a result of scientific research results in a wide variety of fields: (1) communication theory (Claude Shannon); (2) control theory in dynamical systems (Norbert Wiener);[133] (3) the chemical structure of DNA (James Watson and Francis Crick); (4) the relationship between entropy and information (Shannon's information entropy); (5) the problem of information in relation to black holes in the universe (Stephen Hawking); (6) the theory of knowledge (the transformation of information into knowledge); (7) semiotics, and so forth;
- in economics, information is sacrosanct – price, for example, is considered to incorporate all relevant market information (this is also where the origin of EMH lies). Also, many microeconomic (signal theory) or macroeconomic theories (self-fulfilling prophecies, or the Oedipus effect) base their axioms and theorems on the concept of information.

And yet, there are signals still coming from scientific research (i.e., still in the form of information) that things need to be looked at more nuancedly. The most important source for such a change of view comes from biochemistry[134] and indicates that something else comes before information, namely, behaviour. This idea is extremely important, and although Lo does not mention it in any of his papers as having the potential to underpin a new approach to economic research in general, we see it as having this potential. There are, also in the literature in the territory of

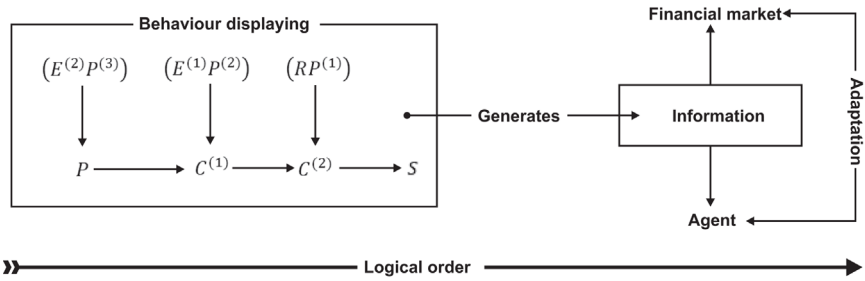

Figure 2.3 The logical primacy of behaviour over information.

Source: Authors.

biology and biochemistry (hopefully, just for now), clear demonstrations (including mathematically formalized) that it is not information (not even that encoded in DNA) that generates behaviour, but conversely, behaviour generates information (Froese et al., 2012). 'Unconsciously', signal theory in microeconomics (e.g., financial theory of the firm) or EMH testing from the perspective of the so-called event analysis appeals to this implicit assumption, that is, the assumption of the primacy of (logical and chronological) behaviour over information.[135] In the original research to be advanced on co-evolution in adaptive preference (in the second volume to be released), the authors will integrate these results in an analytical and, as far as possible, formal way.

In our view, the relationship between information and behaviour[136] (the subject of this paragraph) can be illustrated synoptically as in Figure 2.3.

Adaptation and reaction norm

Representing a variation of fitness[137] adaptation appears as a dynamic and reciprocal relationship between a given entity (in our case, a *trading strategy*) and the environment in which that entity functions (in our case, the financial market – *Nota bene*: we are still in the provisional position of considering the *financial market* as an environment for the trading strategy). In this section we will formalize, rather (for the time being) only from a logical (purely illustrative) perspective, with a broad and quantitative formalization to be dealt with later, both the reciprocal and the dynamic character of the *adaptation* process (and, of course, also of the *exaptation* process; see note 112 on the concept of *exaptation*).

Any variation in the state (structure) and functioning (function) of the adaptant (noted by a) causes a variation in the state (structure) and functioning (function) of the adaptar (noted by A). The magnitude/intensity and speed with which both a and A act and react to each other can be described using the concept of *reaction norm*. We will first analyse the *concept of reaction* in relative detail.

The concept of reaction

The concept of reaction has its origins in Newtonian physics (it is what is called the third law of mechanics)[138] and signifies an action[139] that is caused by another action, the two actions having opposite signs and different origins. This original concept of reaction has several features, namely:

- it is limited to force-type actions (Farmer, 2002);[140]
- it occurs simultaneously with the act;[141]
- it has the same scalar magnitude as the act;
- it has an inverse algebraic sign with the act, which means, in fact, a neutralization, of the equilibrium type, of the impact of the act.[142]

It is easy to see that, from the perspective of economics (both as a praxeological system and as a theory), the established concept of reaction does not verify any of the four defining features of the mechanical concept of reaction. We shall therefore begin this chapter by formulating, on rigorous logical grounds, this concept.[143]

Firstly, we will admit that by action we mean a cause, manifest or potential.[144] That cause originates exclusively in human behaviour (whether individual, group, informal, or institutional), not in nature. This could be a first sufficienc predicate for the concept of act in economics (e.g., not a property but a relationship that the property possibly enables or generates).

Secondly, we will admit that every action has an effect. The effect can occur either directly or indirectly on individuals or groups (an example of an indirect effect: the direct effect occurs on nature, such as the generation of negative environmental externalities, which are then exerted on individuals or groups).

Therefore, by the concept of act, we mean a cause (either manifest, i.e., actually produced, or potential, i.e., produced as a possibility), generated by human behaviour, which generates an effect, directly or indirectl , on human behaviour.[145]

On the basis of the concept of act, we will now develop the concept of reaction.

Firstly, reaction no longer has the obligatory (i.e., logically and ontologically necessary) character that reaction had in the theory of mechanics, that is, reaction is no longer the necessary pair of the act. The reaction may or may not occur as a result of the effect produced by the act.

Secondly, when it occurs, the reaction is not concomitant with the act[146] but is chronologically either later or earlier.[147]

Thirdly, reaction manifests (or, in general, can manifest) the following characteristics compared to act:

- it is not necessarily of the same quantity;[148]
- it is not necessarily of the opposite meaning (e.g., algebraic sign) to that of the act;[149]
- it is not necessarily of the same nature as the act;[150]
- it is not necessarily exercised by the entity (e.g., the economic actor) which has suffered the effect of the ac [151]

A definition of the concept of reaction for the economic (wider, social) domain, which is of interest here, could therefore be the following: *reaction is an act associated, either causally or functionally, with a logically (sometimes also chronologically) prior act, either necessary or contingent*.

Reaction classification criteria

On the basis of the definition obtained for the concept of reaction, it is useful to examine the existence of classes of reaction, that is, to establish a typology of this phenomenon. To do this, of course, we need classification criteria. We propose the following classification criteria for this purpose (Dinga, 2020):

- (CR1) *by temporal sense*: refers to the clock time arrow[152] associated with the production of the reaction;
- (CR2) *by nature of mechanism*: refers to the type of reaction trigger;
- (CR3) *by mode of operation*: refers to the ratio of the effect generated by the act to the expected effect of the reaction;
- (CR4) *by target*: refers to the effect expected to be achieved by the reaction.

Classes of reactions

(CR1) *by temporal sense*

According to this criterion, we can have the following types of reactions:

- (CR1/1) *reactions from the past* (feedback) – this class of reactions operates when the act is prior to the reaction not only logically[153] but also chronologically;
- (CR1/2) *reactions from the future* (feedforward) – this class of reactions operates where the action is chronologically subsequent to the reaction;[154]

(CR2) *by nature of mechanism*

- (CR2/1) *discretionary reactions* – this class of reactions is triggered in a deliberative (usually also formal) way by an agent (economic or institutional, as the case may be);
- (CR2/2) *automatic reactions* – this class of reactions is triggered non-deliberatively but automatically (usually also formally) without directly[155] involving an agent (economic or institutional, as appropriate);

(CR3) *by mode of operation*

- (CR3/1) *stabilizing reactions* – this class of reactions has an attenuating effect (of opposite 'sign') relative to the effect of the act. They refer to both feedback and feedforward reactions. Therefore, we both have negative feedback reactions and negative feedforward reactions;

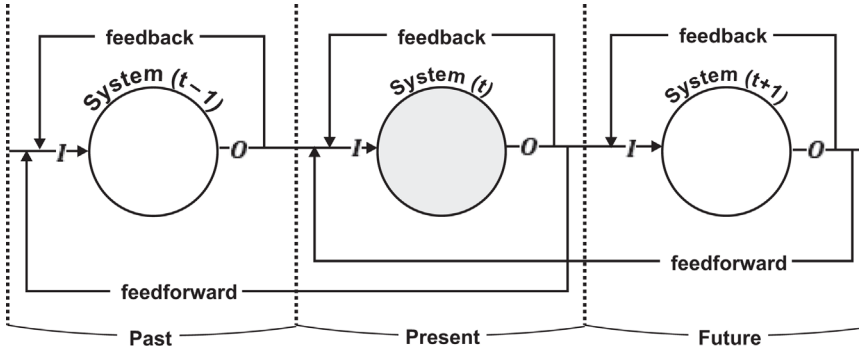

Figure 2.4 Logic scheme of functioning of the reaction of classes CR1 and CR3.
Source: Authors.

- (CR3/2) *destabilizing reactions* – this class of reactions has an escalating effect (of the same 'sign') relative to the effect of the act. They refer to both feedback and feedforward reactions. As destabilizing reactions, we therefore have positive feedback reactions and positive feedforward reactions;

(CR4) *after target*

- (CR4/1) *substitution reactions* – this class of reactions is aimed at producing a substitution effect in the ta get system;[156]
- (CR4/2) *complementarity reactions* – this class of reactions is aimed at producing a complementarity effect in the ta get system.[157]

A synoptic picture of the operation of the reaction from the perspective of criteria CR1 and CR3 is proposed in Figure 2.4.

Reaction norms

The relationship between a and A is dynamic. In addition, it has a circular character, as shown earlier, that is, the act is followed by a reaction which in turn is an act which 'demands' a reaction and so on. Let us introduce a minimal formalization:

- NR_t^a: reaction norm of the adaptant to moment t;[158]
- NR_t^A: reaction norm of the adaptar to moment t;
- SA_t^a: sphere of admissibility[159] of the reaction norm of the adaptant to moment t;
- SA_t^A: sphere of admissibility of reaction norm of the adaptar to moment t.

The adaptation process is, in fact, the integration (endogenization) of the mutual reactions of the adaptant and the adaptar, based on the following validity conditions:

- $NR_t^a \subset SA_t^A,\ (\forall)t \in N$
- $NR_t^A \subset SA_t^a,\ (\forall)t \in N$
- the sequence of reaction rules of the adaptant consists of even indices of t:

$$\mathbb{NR}^a = \left\{NR_0^a, NR_2^a, \ldots, NR_{2k}^a, \ldots\right\}, \text{ with } k \in N$$

- the sequence of reaction rules of the adaptar consists of odd indices of t:

$$\mathbb{NR}^A = \left\{NR_1^A, NR_3^A, \ldots, NR_{2k+1}^A, \ldots\right\}, \text{ with } k \in N$$

- the general sequence of adaptation by reaction rules is as follows:

$$\mathbb{NR} = \left\{NR_0^a, NR_1^A, NR_2^a, NR_3^A, \ldots, NR_{2k}^a, NR_{2k+1}^A, \ldots\right\}$$

Adaptation and exaptation

Adaptation aims, as shown earlier, to achieve the best fitness for a given function of the adaptant operating within a given adaptar. The essential element here is, of course, that there is a function that has a purpose. Note that the entity function is not an effect of the environment but (analogous to the biological function) is an endogenous effect of the entity in question, generated by a mutation, either random, as in the biological case, or via the *modal filter* ($RE^{(1)}E^{(2)}$) discussed earlier, as in the case of the financial market. Particularizing to the case of an agent who trades financial instruments, consider the following hypothetical example:

- an agent develops, on the modal filter path, the following (utopian) function: sensing the degree of persistence of a trend, for example, in the price change of an asset;
- such a function, which is caused (as a mutation) by the 'cooperation' between R and $E^{(1)}$ in the modal filte , will make it possible for the agent in question to exploit the moments in the time series associated with the asset (or the derivative generated by that asset, as the case may be), thus obtaining returns above the market average or, in any case, net returns, that is, above the cost associated with gathering the information and/or assuming the risk of the transaction;
- over time, this function will be used to practice contrarian trading strategies, as follows: when momentum is about to run out (either rising or falling) but has not yet run out, choose a strategy that is contrary to strategies that still rely on momentum inertia;[160]
- this new finality in the use of a function developed, initially, for a different finalit , is called *exaptation* in the specialty literature.

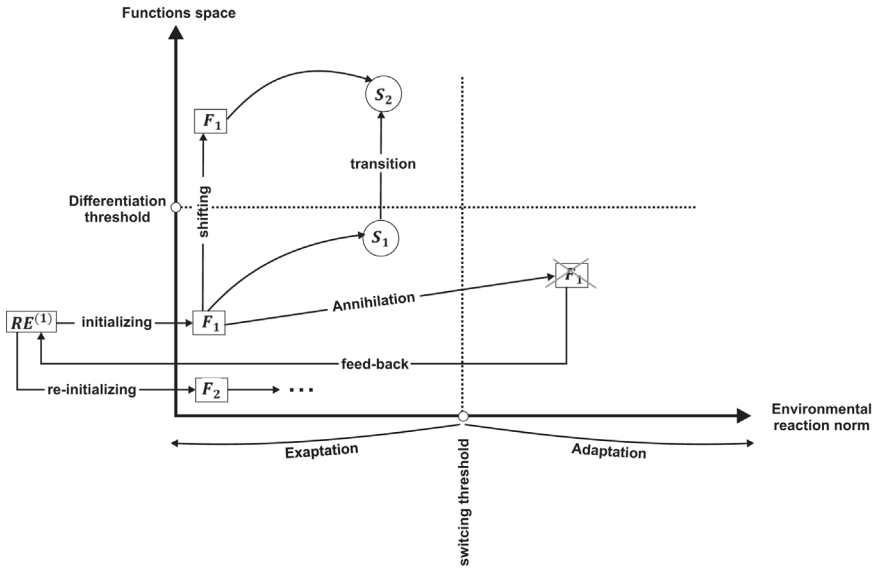

Figure 2.5 Abstract logical relationship between adaptation and exaptation.
Source: Authors.

But what is the mechanism by which *exaptation* occurs? Let us imagine the following situation: a reaction norm of the environment (and received by agent) is situated below the threshold that decisively penalizes an existing function. For example, if the existing function is the one mentioned earlier – the ability to predict the moments of a time series – and the duration of the moments starts to shrink so much that the variation of the time series parameter approaches random walk, then the agent could use the function to exploit the contrarian trading strategy. If the reaction norm decisively penalizes the existing function – for example, moment predictions become increasingly unreliable (fail too often) – then the existing function can be abandoned, so we have an *adaptation process*, not an *exaptation process*. Of course, the criterion that separates the *adaptation* from the *exaptation* is the utility of the trading strategy in question. A graphical picture of the relationship between *adaptation* and *exaptation* can be seen in Figure 2.5 (with F_i it was noted the function i and, with S_i it was noted the purpose i).

Co-adaptation and co-evolution

The distinction between *co-evolution* and *co-adaptation* has been discussed before. In this section we will examine the causality/conditionality relationships, static and dynamic, between the two concepts.

Table 2.1 Logical relations between co-adaptation and co-evolution.

	Co-adaptation	*Co-evolution*
Term	short	long
Finality	individual	species
Cause	efficien [161]	formal[162]
Target	function	structure
Level	micro	macro
Persistence	small	large
Significance	randoberative mutation[163]	cumulative selection

Source: Authors.

As we have seen, *co-adaptation* refers to the *functional adjustments* between the adaptant (*a*) and the adaptar (*A*), which means that it has a static and individual character,[164] while *co-evolution* refers to the *structural adjustments* between the two parties, which means that it has a dynamic and special character.[165] Given the fact (known from systems theory) that structure generates function,[166] it follows that we will also have functional changes as a result of co-evolution, but these functional changes are of a higher order than the functional adjustments generated by co-adaptation. To fix the mutual relationship between co-adaptation and co-evolution, we add the following considerations (Table 2.1).

Therefore, the main conclusions on the relationship between *co-adaptation* and *co-evolution* could be systematized as follows:

- any evolution is co-evolution. Even in the original Darwinian theory, the fact that not only the individual adapts to the environment but also the environment 'adapts' to the individual (more precisely to the species) is a present idea. Neo-Darwinism further supports this double dependence (circular dynamic dependence), and the categories of sympatric versus allopatric speciation, as well as group selection, lead to the same conclusion;
- co-adaptation and co-evolution function, logically (and chronologically, for that matter, given the dynamic causal/conditional relationship between them), in tandem, and they form a necessary (i.e., obligatory) binomial in the functioning process of the adaptive market and, of course, in the functioning process of adaptive preference;[167]
- co-adaptation is conceptually a mutation (*randoberative*, as we propose to call it).[168] In this sense, co-adaptation occurs, successively, in both the adaptant (a) and the adaptar (A), with the 'other' partner performing the selection[169] (i.e., accepting or rejecting the mutation);
- the degree of specialization – of the preference, the strategy or, more generally, the organization – presents a risk of non-adaptability: a small overshoot in the magnitude, intensity, or speed with which the norm of response comes from the co-evolution partner is sufficien for the preference or strategy or organization to be negatively selected (i.e., rejected);[170]

- the co-adaptation – co-evolution tandem is imposed by a simple but universal 'law': the fitness of one species (e.g., the adaptant) depends on the fitness of another species (e.g., the adaptar). Of course, co-adaptation and co-evolution can also occur in both competitive and cooperative environments, with due process differe ces: (a) in *competitive environments*, the fitness of one species moves inversely proportional to the fitness of the other species; and (b) in *cooperative environments*, the fitness of one species moves directly proportional to the fitness of the other species.

From a theoretical point of view, co-evolution (in its necessary pair with co-adaptation)[171] has an alternative. This is the concept of *multi-scalarity* (Gong & Hassink, 2019) which can be defined as the process by which systems are taken over/integrated into supra-systems. This idea is relatively interesting, although it is difficult to demonstrate how multi-scalarity could replace co-evolution – we assume that a (logical) link could be established between co-evolution and multi-scalarity analogous to the link established between co-adaptation and co-evolution, but we will not develop this suggestion further here.[172] Moreover, as we see further on (see section "Selection and self-organization/autopoieticity"), another 'competitor' to co-evolution (more precisely, in fact, to selection) appears, namely, self-organization (or, more broadly, self-poieticity).

Expectation and anticipation

The concept of expectation, both in its subjective and mathematical sense (i.e., the so-called rational expectation), was highlighted, succinctly, in Chapter 1 – whereas in its subjective version, expectation is a simple granting of Bayesian probability *a priori* to a future event,[173] mathematical expectation is based on a statistical moment[174] type calculation (it is thus, technically speaking, a moment of the order 1). The expectation in its mathematical sense[175] underlies the theory of rational expectations,[176] developed within the framework of neoclassical economic theory. Regarding the (semantic and functional) rapports between the two concepts – expectation and anticipation – we can say the following:

- both concepts are about future events;
- whereas expectation refers to a subjective, completely idiosyncratic feeling, without any formalization external to consciousness, anticipation refers to a calculation external to consciousness (though driven, of course, by consciousness) based on a pre-accepted model of rationality;
- both concepts are based on belief – the concept of belief must be considered very close (but, however, not exactly identical, as we will show later) with the concept of preference;[177]
- while expectation is not visible to others and is not interpersonally communicable – except, of course, through the objectification of the action generated by it – anticipation is (or can be) visible to others, precisely through the calculus based on the assumed model of rationality. For example, someone who

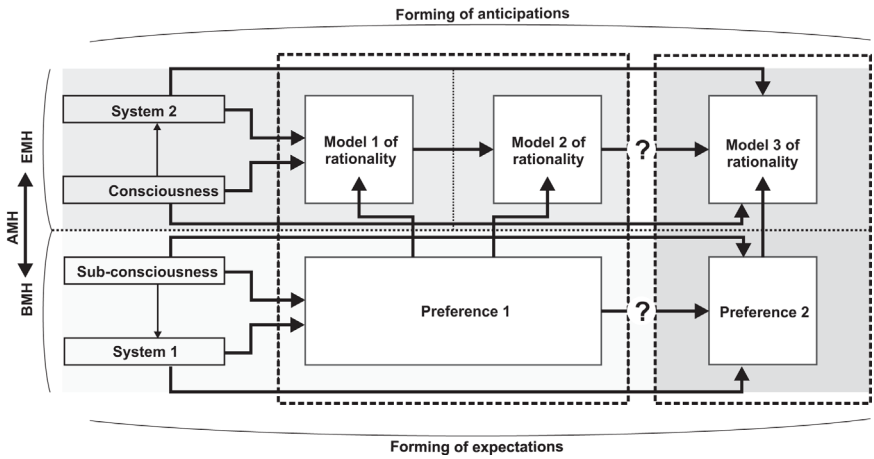

Figure 2.6 Abstract logical relationship between expectation and anticipation.

Source: Authors.

assumes the *homo œconomicus* model will be 'visible' to others about what decision he will make in a given situation because that decision (choice) must be a valid inference from the model of rationality in question;

- in terms of its nature, the expectation is a pre-intellectual state of consciousness (it is often 'located' in the subconscious), while anticipation is an intellectual state of consciousness (it exists only in the conscious);[178]
- in terms of stability, expectation/preference is persistent (sometimes lifelong), while anticipation lasts as long as the acceptance of the model of rationality with which it is associated. Of course, this does not mean that the model of rationality changes very often, but relatively speaking, it is much more unstable than expectation – for example, risk preference may persist even if the EMH model of rationality is replaced by the AMH model of rationality.

In the context of the discussion in this study, the rapport between expectation and anticipation can be rendered synoptically as in Figure 2.6.

Exogeneity and endogeneity in the functioning of adaptive preference

Based on the two previous discussions (reaction norms and the relationship between expectation/preference and anticipation/model of rationality), another issue becomes important now, namely, the relationship between exogenous and endogenous in the functioning and dynamics of adaptive preference.

In the specialty literature, opinions cover the whole spectrum of options – to consider the environment completely endogenous for the change of preference or, on the contrary, to consider it completely exogenous. For example, with

regard to the financial market considered as representing the environmental component, Grossman and Stiglitz believe that the number of informed agents (i.e., those who can exploit the opportunities created on the market by the uninformed – the latter being those who introduce noise to the market) represents an endogenous variable (Grossman & Stiglitz, 1980). In the same note, Lo chooses to consider systemic risk – that is, risk 'coming' from the market to the agent – as endogenous (Lo, 2019). Weick (2015) positions himself in a middle position (theoretically prudent but vulnerable from a methodological and instrumental point of view) arguing that the environment must be considered, from the agent's perspective, both as an endogenous variable and as an exogenous variable. On the other hand, there are authors who appreciate the environment (from the perspective of institutional change, this time) as representing a control problem rather than an endogenous effect (van den Be gh & Stagl, 2003).

The endogenous and exogenous properties are respectively dependent, including from a causal point of view, on the type of social/economic game in which these properties are examined:

- if we are in a *win-win* game,[179] that is, within a cooperation, then the market signals (i.e., at the limit, of the economic game partner) are endogenized, so it must be considered endogenous – this endogenization is done, obviously, through reaction norms (discussed in section "Reaction norms");
- if we are in a *win-loss* game, that is, in a competition, then the market signals (i.e., at the limit, of the economic game partner) have an exogenous character. The win-loss game can go as far as the (economic) extinction of one partner (biological equivalent: of one species) is caused by the actions of the other partner (biological equivalent: the other species);[180]
- the question is whether there is a *loss-loss* game. Logically, this would mean that the amount of winnings (e.g., the sum of the substantive utilities) of the two partners decreases compared to the moment before the start of the game, so regardless of how the loss is distributed between them,[181] both lose. This can happen, for example, in the event of a war, in which resources are destroyed (and made unavailable) for both partners or in another similar circumstance – an example in the financial market is the stock market crash, in which, in principle, everyone loses.

In fact, a synoptic of all possible cases in this sense is the following (Table 2.2) (*prop*. expresses the case 'proportional to the assumed risk/cost', and *non-prop*. expresses the case 'un-proportional to the assumed risk/the cost').

The way in which the endogeneity and the exogeneity of the impulse/cause are correlated with the adaptive preference can be described as follows:

- endogeneity implies rather co-adaptation, that is, an adaptation at the level of the functionality, not of the structure. From the perspective of adaptive preference, this means that preference will adjust not to the level of belief

Table 2.2 An abstract typology of the economic game.

			Agent 2			
			win		*loss*	
			prop.	*non-prop.*	*prop.*	*non-prop.*
Agent 1	*win*	prop.	S_{11}^{11}	S_{12}^{11}	S_{11}^{12}	S_{12}^{12}
		non-prop.	S_{21}^{11}	S_{22}^{11}	S_{21}^{12}	S_{22}^{12}
	loss	prop.	S_{11}^{21}	S_{12}^{21}	S_{11}^{22}	S_{12}^{22}
		non-prop.	S_{21}^{21}	S_{22}^{21}	S_{21}^{22}	S_{22}^{22}

Source: Authors.

(the deep layer of foundation of the preference) but to the level of the external manifestation of the preference (choosing the trading strategy);

- exogeneity implies, on the contrary, a co-evolution, that is, an adaptation at the level of structure, not at the level of simple functionality. For example, an endogenous (or equivalent, endogenized) impulse described as 'reducing the positive self-correlation interval of time series observations'[182] will lead to replacing the risk minimization preference with a risk-seeking preference, such as choosing contrarian strategies.

Of course, from a practical standpoint, distinguishing between endogenous causal or conditional impulses and such exogenous impulses is far more difficul than the purely academic approach suggests. The difficult is also increased by the ambiguity between endogenous and endogenized exogenous and between exogenous and exogenized endogenous. But methodological and instrumental solutions to overcome the difficultie can be found on a case-by-case basis. In our opinion, the logical (and to some extent quantitative) 'operator' that can help to make these distinctions is precisely the reaction norm.

Adaptive preferences and level of aggregation

There are opinions (Acemoglu; Robinson, 2019) that claim that the macro level does not exert constraints on the formation or the dynamics of preferences (not only on economic preferences, of course, but relative to any kind of preferences – for example, the preference for freedom or, diametrically opposed, for dictatorship/paternalism). Not only in connection with this opinion but also in a broader context of the relationship between the micro level and the macro level (especially specified in the economic case or even customized in the financial market), we make the following considerations.

The 'headquarters' of the change of preference (i.e., the 'headquarters' of the adaptive preference) can only be the individual, namely, the investor, who is still the economic operator trading on the financial market. The reason is that beliefs, on which preferences are based,[183] are idiosyncratic subjective properties of the individual.

From an evolutionary point of view (more precisely, co-evolutionary), therefore, the mutation regarding the preference occurs at the micro level of the individual. Of course, taking into account the so-called group selection (which we will return to), we can extend the target of mutation to the group level[184] (considered according to various criteria), but, even in this case, we are still talking about the micro level.

The question now arises as to the source/origin of the impulse for mutation. In our opinion, there are two such sources: (a) internal sources – the individual (or group, as the case may be); and (b) external sources, that is, the environment (financial market):

- the internal (endogenous) source is a *micro* source type, and the way in which it appears (occurs) is rather deliberate (more precisely, quasi-deliberate), the mechanism involved being a kind of self-reaction norm, that is, a norm of reaction applied in the loop. In a more analytical development, the internal source of the mutation could be considered from the perspective of the modal filter $RE^{(1)}E^{(2)}$, and in an analogy with the biological phenotype, it has the effect of developing (not evolution) [185]
- the external (exogenous) source is a *macro* source type, even if, for example, it is located at the level of another economic agent. The main argument in this regard is that the norm of reaction of another individual represents a wrapper of the state of the environment, that is, the financial market – the macro level of aggregation of the economic process.

Adaptive preference is considered adapted (or re-adapted) only after the environment (financial market) has selected it cumulatively, that is, in turn, has preferred it. Unlike in the case of mutation, in which the random nature of the biological domain has been replaced by the quasi-deliberate character in the field of the financial market, in the case of cumulative selection, it occurs in both domains in a similar way, that is, in a directed way – the directed selection criterion is the adequacy[186] of the fitness, or rather, of the new fitness appeared after the mutation, to the environment (to the financial market).

Therefore, the mutation occurs either at the micro or at the macro level (analogous to the production of the mutation in the biological field) [187] while cumulative selection always occurs at the macro level (or, more precisely, is exercised from the macro level).

The problem of *punctuated equilibrium*[188] in selection (which obviously also acts from the macro 'direction') is, in our opinion, of the greatest significance in the logical (and, subsequently, quantitative) modelling of the functioning of the financial market and, as a result, in the functioning of adaptive preference: the 'target' of our study. In this sense, we consider that, for the economic case (in this

case, for the financial market), the concept of punctuated equilibrium has the following logical properties:

- it is not much rarer than cumulative selection in terms of frequency of occurrence;[189]
- the selection made by the financial market is probably based on a mix between cumulative selection and punctuated equilibrium;
- the punctuated equilibrium produced on the financial market is a mixed effect within the modal filter so that deliberativeness R is adjusted by experience $E^{(1)}$ and directed by emotion $E^{(2)}$.

The co-evolution (partially also co-adaptation) between preference and the financial market implies the alternative change of the position of the two components from the perspective of characterization as micro level and macro level.

Adaptive preferences and synergy

The rapports between adaptive preference and synergy target, in fact, several concepts that describe the phenomenology of these rapports, including emergence, selfishness, altruism, parasitism, symbiosis, and so forth. We will first proceed to fix the concepts.

Synergy: the synergy is *a property of a system* to have properties that appear only as a result of its formation as a system. This means that these new properties cannot be found on components as they are outside the system. Of course, these properties are subject to interpretation – they may be desirable or they may be undesirable, for example. The most important aspect is related to their predictability. Thus, knowing in advance what components a system is about to form, we could know, anticipate, of course, based on pre-accepted models of rationality, the synergistic properties of the future system – this is *predictable synergy*. If, however, once the system is formed, we observe/measure new properties that we have not been able to anticipate, we are dealing with *unpredictable synergy*. Of course, in principle, both forms of synergy are possible within the same system.

Emergence: an emergence is *a process* that refers to the appearance of a thing, property, or relationship without that appearance being either an inferred result from a model of rationality or an expected result by an action (act or abstention, as the case may be). Given that the emergence already contains, in its concept, the predicate of novelty – the predicate of being something new – it follows that there is a semantic equivalence between emergence and unpredictable synergy, in the sense that any unpredictable synergy is an emergence and vice versa.

Selfishness: selfishness is *a property of a behaviour* that refers to the structural tendency (belief or preference) to pursue the achievement of an individual goal, regardless of the impact of this behaviour on others. Of course, selfish behaviour does not necessarily lead to a negative (disadvantageous, unfavourable) impact on others[190] – it simply ignores the interests and goals of others. From a moral point of view, there are, of course, problems generated by the

violation of the Kantian maxim of behaviour (Wright, 2002) – behave as if you always agreed that your norm of behaviour should become the norm of behaviour of society[191] – in the sense that by this violation, other individuals (participating in the social or economic game) are treated as (only) means of achieving their own goals.[192] Selfishness is a principle of behaviour that is 'recorded' in our genes; it is one of the means by which we have survived throughout history (and, of course, long before the beginning of history[193]), and behaviourism, coming from psychology to economics, successfully exploited this evolutionary given in describing the real economic behaviour, not the one imagined by the neoclassical economic theory.

Altruism: altruism is *a property of a behaviour* that refers to the tendency (either structural or exclusively functional) to act in favour of another (individual or group), even if, most often, to the detriment of pursuing the selfish purpose. The problem of the essence of altruism is still unresolved by consensus, both at the level of economic theory and at the level of moral philosophy. Opinions cover the whole spectrum of interpretations: from the brittle opposition of altruism in relation to selfishness to the consideration of altruism as a disguised selfishness. It seems, however, that on at least two issues the vast majority of analysts agreed, namely, (a) that altruism involves an individual cost supported by the altruist and (b) with the fact that altruism works in group selection (Floreano & Mattiussi, 2008). Both assumptions are obvious, so we will not develop here further.

Parasitism: parasitism is a *behavioural relationship* of reaping benefits from living with another individual (either of the same species or of another species and even of another genus) without the other individual benefiting from any advantage, in turn, resulting from this co-existence. It is, as we will see in the concept of symbiosis, an asymmetric symbiosis, or an amputated symbiosis, or, again, a one-way symbiosis. Parasitism is widespread in the biological world and, of course (perhaps even more so), in the economic world.[194] In fact, parasitism can take very subtle forms (unrecognizable *prima facie*) that can go so far as to constitute successful trading strategies, which leads to the need to take them into account even from the perspective of adaptive preference; thus, an adaptation of preference can produce exactly on the margin (either as a goal or as a means) of parasitism. For example, in the discussion on the role of information in co-evolution (see section "Information and behaviour") and in behaviour, respectively, the methodology to demonstrate that it is not the information that generates the behaviour, but conversely, the behaviour that generates the information[195] uses exactly the parasite hypothesis (introduced by an appropriate differential equation, it is true, however, that at the level of pre-cellular or pre-biotic behaviour) (Froese et al., 2012).

Symbiosis: symbiosis is a *behavioural relationship* through which two partners (symbiotic partners) achieve mutual positive synergy. Symbiosis can be interpreted from two perspectives: (a) as suggested earlier, symbiosis is a symmetrical parasitism; and (b) symbiosis is a *win-win* cooperation.[196]

The relationship between adaptive preference and synergy can be described by the following considerations:

- positive synergy has an effect of strengthening preference,[197] while negative synergy has an effect of undermining it;
- from a technical point of view, both strengthening and undermining the preference are cases of adapting it – it can also be said that strengthening the preference is a conservative adaptation of the preference, while undermining the preference is an innovative adaptation of the preference;
- logically, any manifestation (objectification, use) of the preference can only be made through interaction with other market participants. This means the formation of new systems or supersystems on the financial market (even if temporarily), but the simple formation/reformation of systems generates, as we have shown, synergy, either positive or negative;
- the impact of synergy on adaptive preference[198] is inevitable. Specificall , this impact is necessarily conditional: generating synergy is unnecessary (as financial market trading is unnecessary), but once the economic game is initiated (this initiation represents the conditional), the emergence of synergy is necessary;
- one of the ways to 'beat' the market also lies in exploiting the predictability of synergistic effects (either positive or negative). From a conceptual point of view, therefore, an equivalence can be accepted, on the financial market, between noise and emergence.[199]

Selection and self-organization/autopoieticity

Self-organization is a kind of autopoieticity, because autopoieticity provides, in addition to self-organization and other functions of the same category, self-repair, self-catalysis, and so forth. From the point of view of the research subject in this study, the most relevant aspect is that self-organization can be an alternative to selection. Both standard Darwinism and the new Darwinism (or generalized Darwinism[200]) are projected on the two intercorrelated processes which, in their interdependence, describe the evolutionary process: (a) random mutation, at the level of genotype; and (b) directed cumulative selection, at the level of the phenotype. Research in the matter of evolution (not only biological/natural but also, especially, social/cultural) shows that the evolution can take place in two alternative ways which, very importantly, are not inconsistent with each other but, in fact, constitute two 'channels' or two evolutionary stages, the second 'channel' being precisely self-organization.

Self-organization is also present in non-living nature (at the pre-biotic level) but, of course, especially in living nature and the cultural field. In the cultural field, the automatism of self-organization (Eigen, 2013) in the non-living world or in the non-cultural living world, based on the hypercycle, is replaced with

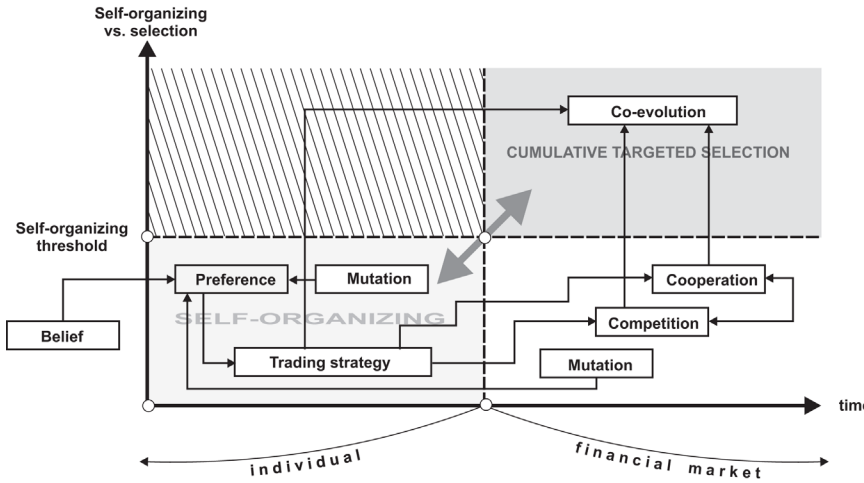

Figure 2.7 The logical relationship *self-organization–selection* in the evolutive process of the adaptive preference.

Source: Authors.

deliberativeness and, especially, by the intellectual project. Conceptually, self-organization in the cultural field – for example, on the financial market or at the level of the individual, either as a preference or as a trading strategy – is analogous to co-adaptation and, quite frequently, co-exaptation. Of course, self-organization itself, above a certain threshold, must be validated by the environment, thus being ultimately subject to selection, so it can be said that self-organization is an intermediate internship/stage between mutation and selection. In other words, self-organization is a substitute for selection until a threshold of variation generated by self-organization is exceeded, which leads to the confrontation with the constraints imposed by the environment and when, therefore, the selection comes into operation.

In logical modelling and, especially, in the quantitative modelling of adaptive preference, self-organization and, as seen in other sub-objectives of the study, autopoieticity are important factors in dealing with the real (realistic) process of economic behaviour on the financial market.

A graphic suggestion of the relationship between self-organization and selection in terms of adaptive preference may be that in Figure 2.7.

Adaptation, specialization, and success

In the problem of adaptive preference, there is a problem (which is encountered, it is true, in any evolutionary process, so in any adaptive process); it is

about the degree of specialization. A system 'immersed' in its environment must be compatible with the environment, after it has avoided being inconsistent (i.e., contradictory) with it. But the question is: how compatible must it be with the environment? There is the following issue, which is, of course, also encountered in the biological field, but is becoming increasingly important in the cultural field, that is, in the human economy and society: specialization, which is an effect (among others) of adaptation, including co-evolution, becomes, above a certain threshold, a vulnerability. The phenomenon can be described as follows:

- the system adapts, both under the pressure of internal factors and under the pressure from the environment, so that it is selected by the environment, which is equivalent to winning the 'bet' of survival;
- from an objective point of view, adaptation leads, by accumulation, to specialization; therefore, specialization represents a narrowing of the area of interaction with the environment, accompanied (in a non-linear correlation) by an increase of the efficienc of the system in interaction with the environment;
- increasing the yield is possible, therefore, in the context of specialization, only at the cost of narrowing the area of interaction with the environment: this is called *niche* or *niching* process;
- therefore, niche reduces the number of degrees of freedom of the system in ensuring its survival; as a result, any reduction in the capacity of the occupied niche to meet the survival criteria of the system constitutes insurmountable risks (at least in the short term) for that system;
- if the question is asked, how far should specialization be taken, the answer should obviously take into account the criterion of validation of the behaviour; while EMH, for example, would require maximum degree of specialization, or niche, in order to obtain the maximum gain (*first best*) from exploiting market opportunities (even if the market, of course, becomes efficien in the sense of Fama after exhausting those opportunities), this also leads to the maximum degree of vulnerability (potential risk). AMH would require less and, namely, survival (*second best*), which stops the degree of specialization at a reasonable level (*Nota bene*: it must be specified, of course, what is reasonable), so it prevents too much narrowing of the niche in which that system 'lives'.[201]

Figures 2.8 and 2.9 offer synoptic images of the relationship between specialization, yield, and vulnerability (e is the elasticity of the interaction area – or the niche of the system) depending on its degree of specialization: $e = \frac{\Delta A}{A} \cdot \frac{S}{\Delta S}$).

Therefore, if we note by $s(r)$ the specialization function, where with r the risk was noted, and with $n(r)$ the niching function, then, from a quantitative

point of view, we can write successively (*Nota bene*: x' means the derivative of order 1 of the function x, and x'' means the derivative of order 2 of this function):

$$n(0) = 0$$

$$n\left(r^{M}\right) = 0$$

$$n\left(r^{*}\right) = M^{s}$$

$$\begin{cases} n'(r) > 0, pt.\, r < r^{*} \\ n'(r) = 0, pt.\, r = r^{*} \\ n'(r) < 0, pt.\, r > r^{*} \end{cases}$$

$$n''(r) < 0$$

$$s(0) = 0$$

$$s\left(r^{M}\right) = M^{s}$$

$$s\left(r^{*}\right) = c^{*}$$

$$s'(r) > 0$$

$$\begin{cases} s''(r) > 0, pt.\, r < r^{*} \\ s''(r) = 0, pt.\, r = r^{*} \\ s''(r) < 0, pt.\, r > r^{*} \end{cases}$$

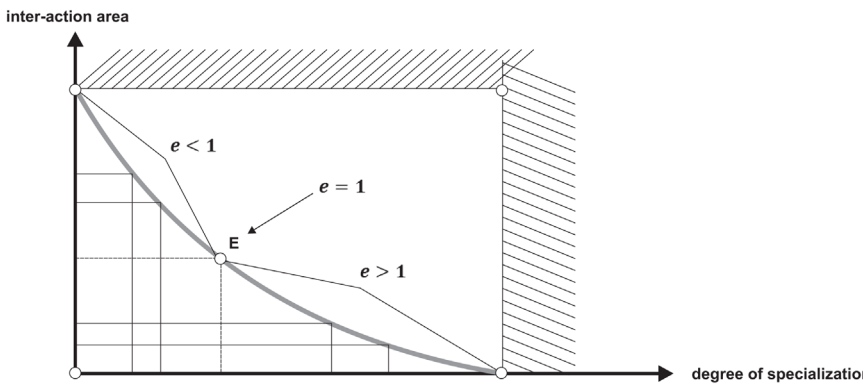

Figure 2.8 Dynamic relationship between the degree of specialization and the inter-action area (niche).

Source: Authors.

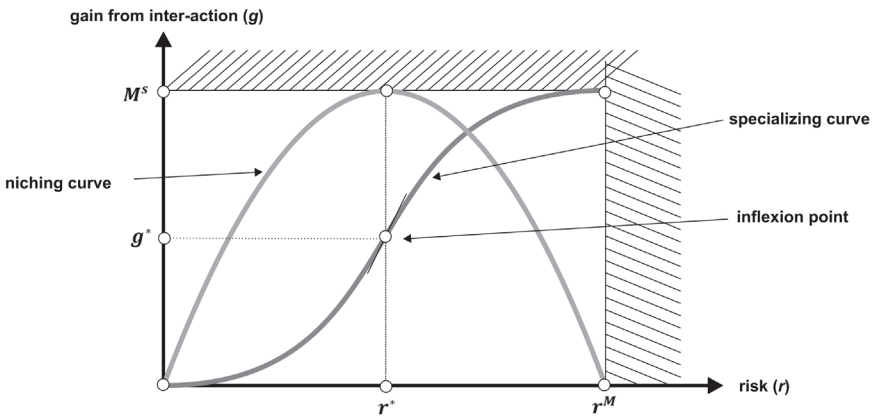

Figure 2.9 The specializing curve versus the niching curve.

Source: Authors.

The internal logic of financial market models

Based on the examination of the two models (three, if we allow that BMH would represent such a model; the idea is rejected, however, by Lo) of the financial market and, moreover, of any behaviour of choice (not only in terms of economic phenomenology), it seems that, from a historical point of view, we have a non-overlap of the order in which these models appeared with the logical order in which they should have 'appeared'.[202]

Thus, given that the fundamental criterion of behaviour, that is, choice (and which has subsisted and still exists throughout the entire evolutionary process of the man) is the criterion of survival, the first model, in logical order, meant to describe real behaviour of the individual, is obviously BMH. Based on the reciprocal reactions (reaction rules) between the individual and his environment – in this case, between the trading strategy and the financial market – the second pattern of behaviour should have been that of AMH. Finally, as rationality, accompanied by the preponderance of deliberativeness, teleology, and morality, develops, EMH should have emerged.

The historical reversal of the emergence of logical models of the economy (and of the financial market) compared to the logical order seen earlier overlaps with an analogous 'anomaly' recorded in the matter of praxiological models followed by the humankind. Thus, the first praxiological model was that of stationarity, identical to the 'model' followed by the non-human living world; the second was that of optimality; the third (emerging) is the model of sustainability; and the fourth (which, in our opinion, will have to be built teleologically) is the praxiological model of viability. And in the case of praxiological models, it seems that

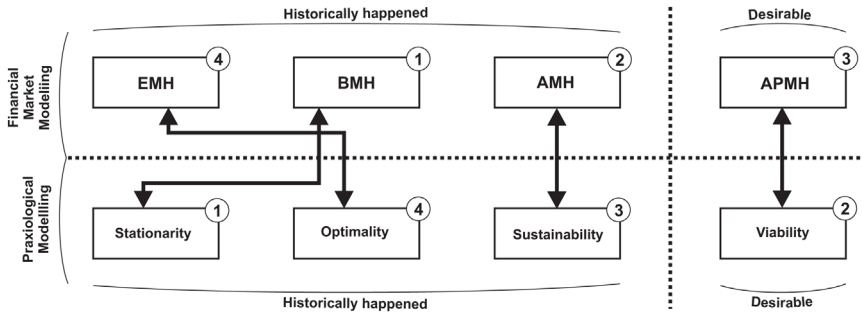

Figure 2.10 Historical 'anomalies' and logical correspondences between financial market models and praxiological models.

Source: Authors.

optimality has 'jumped' over the line, as happened with EMH. By mirroring the kinematics of the logical models of the financial market with the kinematics of the praxiological models, these 'anomalies' can be represented as in Figure 2.10.

A draft of a logical model of adaptive preference in the financial market

Preamble

In this section a logical (qualitative) model of adaptive preference on the finan cial market will be proposed. The proposal is based on the results obtained in Chapter 2. The model concerned is characterized by the following:

- it is a *main model* – this means that it does not contain quantitative formalizations but only qualitative suggestions of mechanism;
- it is a *co-evolutionary model* – adaptive preference is considered to be the entity/system that adapts (i.e., the adaptant, previously denoted by a) under environmental pressure (i.e., the adaptar, previously denoted by A) but at the same time takes into account the (necessary) change of 'roles' when the adaptant becomes adaptar and the adaptar becomes adaptant. Of course, co-adaptation and co-evolution act simultaneously, as shown earlier;
- it is a *causal/conditional model* – the cause of the change in preference may be both the mutation that occurred at the level of preference and a change in the environment (by simplification, on the financial market) which is, however, endogenized. The same happens with the environment: it may suffer a mutation – for example, an institutional change[203] occurs – or it can react, through its own reaction norm, to a change in preference (which, in turn, it endogenizes). Therefore, co-evolutionary adaptation is not only causal

(mutation) but also conditional (acceptance of mutation by the 'partner'). Thus, in the literature it is appreciated that each individual strategy is characterized by a market-induced dynamic (Farmer, 2002);

- it is a *dynamic model*[204] – preference adapts and, as an effe t, co-evolves under the rule of causality. Although causality always occurs deterministically (i.e., analytically),[205] in the economic field, the very complicated nature of the processes forces us to study it in its statistical aspect (i.e., on average). The statistical character of causality does not eliminate causality from individual cases; it only puts it under the impact of the population hypothesis/conjecture;[206]
- it is a *genetic model* – the concepts of mutation, adaptation, and co-evolution (which are concepts proper to biological dynamics) somehow suggest (or represent an invitation to) the direction of genetic analysis of the problem of adaptive preference. Such a suggestion will be developed by the authors in Volume 2 to be released, in the form of the *Autopoietic Market Hypothesis* – APMH).

Therefore, although we consider the co-evolution (as a necessary process) of *preference* – (financial) *market*, the emphasis will be mainly on the behaviour of preference (and on the variation in the choice of trading strategy).[207] The specificity of our approach, compared to the approach taken by Lo (2019), consists, in essence, in the following:

1 the prime factor in the *preference-strategy* pair is preference; of course, the choice of strategy is not exclusively the effect of preference, but the other causal/conditional factors (e.g., those in the modal filter discussed earlier) in this choice are subsumed to preference or manifest in the margin of preference. Consequently, scientific interest must be focused on the dynamics of preference (which, enduring dynamics, can only be an adaptive preference);
2 ultimately, the financial market itself (as an aggregate of individual adaptive preferences) evolves precisely to adapt to these preferences but not as an environment that sovereignly selects preferences (as is the case – though, here too relatively – in the biological field and in the conception of AMH) but as an environment that is simply the expression of these adaptations of preference;
3 consequently, an intermediate model of our research (up to the formulation of APMH) will be that of the *Adaptive Preference Hypothesis* (APH).

Principles

In general, a logical model[208] is based on three categories of principles: (a) *institutive/structural* principles, which create the structure of the model in question; (b) *distributive/functional* principles, which ensure the functioning of the institutive principles; and (c) *regulatory/selection* principles, which ensure the

maintenance of the distributive principles on the 'corridor' indicated by the institutive principles.[209]

In the case of the logical model of adaptive preference in the financial market, we consider that the following principles should be remembered and used:

a. institutive/structural principles (IP)

(*IP* / 1) *survival principle* (or *second-best* principle): it is the guiding principle of adaptive preference behaviour, replacing the principle of optimization (or, equivalently, the principle of minimizing opportunity cost or, again, the *first best* principle) of models based on the theory of rational expectations (as is EMH);

(*IP* / 2) *the principle of* heuristic representativeness:[210] it is the principle that describes the real way in which individuals make decisions (make choices), in a fast, simplified way, based on the successful experience (*rule of thumb*).[211]

b. distributive/functional principles (DP)

(*DP* / 1) *preference principle* (or modal filter principle): it is the principle that describes the behaviour of individuals, from the perspective of choosing trading strategies, by using the modal filter procedure $\left(RE^{(1)}E^{(2)} \right)$. This is the general (paradigmatic) mode of functioning of the logical model of adaptive preference – more precisely, this is the basic function generated in this model;

(*DP* / 2) *choice principle* (or nominal filter principle): it is the principle that provides the second function of the adaptive preference model, based on the nominal filte .

c. regulatory/selector principles (RP)

(*RP* / 1) *principle of reactive norm*: it is the principle that ensures the fetality of the interactions between the adaptant (a) and the adaptar (A), by framing the reactions (more precisely, the reaction norms) of the two partners in the respective admissibility spheres;[212]

(*RP* / 2) *the principle of co-evolution*: it is the principle that ensures the dynamics of preferences (implicitly of the behaviour on the financi l market); moreover, co-evolution constitutes, in this research, the general theoretical foundation.

Logical analysis of the principles

The principles governing the logical model of adaptive preference are established lexicographically so that the institutional principles stay, in importance and

relevance, before the distributive principles which, in turn, stay in importance and relevance, before the regulatory principles. The choice of lexicographical order in the case of principles is obviously without alternative: if one were to look for a criterion for ordering principles, it should be of an order of primitivity superior to the order of primitivity of the principles to be ordered. From a semantic (but also logical) point of view, primitivity has no degrees, so no criterion can be found (which, obviously, cannot, in turn, be then a principle) which is more primitive than the principles themselves which are required to be ordered. Consequently, there is no solution to ordering principles other than that of lexicographical ordering.[213] We will present some (general) considerations regarding lexicographic ordering:

- it is an *a-criterion* ordering: lexicographical ordering does not need an ordering criterion (classification) that 'assigns' to each principle an order number;[214]
- *a-criterion* ordering has a *necessary* character: suppose we intend to find a criterion that generates lexicographic ordering. Identifying a criterion is, in turn, a selection process that requires a selection criterion and so on. We have, here, a process of regression *ad infinitum*, that is, insoluble;
- consequently, lexicographical ordering must be based on discretionarity;
- discretionarity is ensured by (is based on) *belief*;
- the form of external manifestation (or objectification) of belief is known as *preference*;
- in turn, preference may be of the *rational* type (belief in a model of rationality[215] – for example, in the *homo œconomicus* model) or of the *a-rational* type (metaphysical type of belief);
- rational preference is not a free decision (it has nothing to do with free will), while a-rational preference is a *free* decision.

Of course, post-factum analysis can reveal, for example, on a consequential[216] basis, the 'correctness' of lexicographic ordering. In our case, it is obvious that we must first design the structure of the model (which gives it both personality and persistence) – that is, the principles of the institutive class – then the functionality that is necessarily provided by the structure – that is, the principles of the distributive class – and finall , the homeorhesis[217] of the model must be ensured – that is, the principles of the regulatory class.[218]

The ordering of the (proper) principles, within each of the three classes of principles, is (and must be) also done on a lexicographical basis. So:

- regarding the class of institutive/structural principles: $IP/1$ is lexicographically earlier than $IP/2$ because, in order to make choices based on (or conditioned by) the heuristic of representativeness,[219] there must be an agent to make that choice, that is, it is necessary for the agent in question to survive (*Nota bene*: of course, we have in mind, here, an economic survival, for example, the success of the trading strategy, and not a biological one, which is assumed, in turn, to be previous, lexicographically, to economic survival);

- regarding the class of distributive/functional principles: $DP/1$ is lexicographically earlier than $DP/2$; the principle of preference (or modal filter) is (see section "Adaptive preference and adaptive market") formalized by the triplet $RE^{(1)}E^{(2)}$ where R is rationality; $E^{(1)}$ is experience (including experiential memory); $E^{(2)}$ is the emotion (including the animal component of the human individual), which lexicographically prevails over the principle of choice (or nominal filter) formalized by the triplet (the three P's of Lo) $P^{(1)}P^{(2)}P^{(3)}$ where $P^{(1)}$ is the price, $P^{(2)}$ is the probability, and $P^{(3)}$ is the preference. Thus, the price $P^{(1)}$ is evaluated both through the prism of R and through the prism of $E^{(1)}$, the probability $P^{(2)}$ is evaluated both through the prism of R and through the prism of $E^{(1)}$, and the preference $P^{(3)}$ is the result of the evaluation to which it contributes, on the one hand, $E^{(1)}$, and on the other hand (and, moreover, decisively), $E^{(2)}$;
- regarding the class of regulatory/selector principles: $RP/1$ is lexicographically earlier than $RP/2$; indeed, logically, in order for co-evolution to take place, it is necessary (not necessarily sufficient but the condition of sufficiency will be examined later) to produce reaction norms between the adaptant (a) and the adaptar (A), in accordance with the formal conditions set out in section "Reaction norms".

The general mechanism of the principles operationalization

The mechanism that these principles generate regarding the adaptive preference can be represented synoptically as in Figure 2.11 (with TS was noted as the *trading strategy*).

Catalysts, cycles, and hypercycles

Catalysts

We talked earlier about adaptation (which is, in fact, always, co-adaptation) and about evolution (which is, in fact, always, co-evolution), in terms of preference and, more broadly, the economic agent shaped by preference. There is, however, as we will see, self-adaptation and self-evolution. These last two concepts correlate with the catalyst concept. *Catalyst* (a term derived from chemistry and later from biochemistry) means a factor, either material/substantial – that is, likely to generate material causality – or cultural/institutional – that is, likely to generate formal causality – which stimulates a process without itself being transformed during that process. Examples of material catalysts are enzymes from biological processes, and examples of cultural catalysts are religious systems or positive normative frameworks in society.

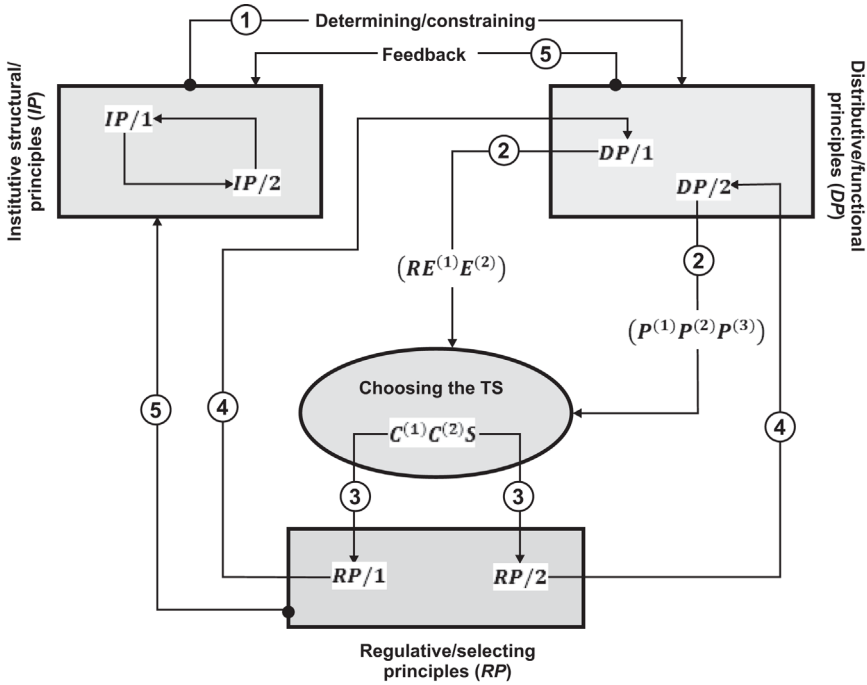

Figure 2.11 The general mechanism of the principles of the logical model of adaptive preference.

Source: Authors.

The question arises as to whether there are catalysts also in terms of the functioning of the financial market and in terms of adapting the preference within the agent-market 'game'. Our opinion is that, in a very broad sense, such catalysts can be identified, and in the following discussion, we will outline some considerations in this regard. But first, the sufficiency predicates of the catalyst concept m be established:

1 it is a factor/variable *distinct* from the factors/variables participating in the process of interest;
2 it is *indispensable* to the process of interest, with the condition that the process has to be 'provided' with catalysts (there are, of course, processes that do not have associated catalysts – for example, the purchase of drugs is prohibited without questioning the eligibility of buyers);
3 it has a *conditional*, not a causal, impact;[220]
4 it has a *performative* impact – in the sense that it acts in the direction of stimulating the production of the result, not in the direction of inhibiting the production of the result;[221]

5 it is *non-autonomous* – in the sense that a particular catalyst is functionally associated with a particular process and often even a specific cause specific to that process, so it is not of general 'applicability';[222]
6 it is *non-independent* – in the sense that it cannot act on his own; its action occurs only if a cause occurs (or has the potential to occur);
7 it is *non-sufficient* – in the sense that, even if its action is up-to-date, the absence of the cause necessarily leads to the absence of effect.

From the perspective of logical modelling of the phenomenology of adaptive preference, catalysts are of significant importance, because the change/variation of preference can occur either anticipatively or retrospectively, precisely as a result of the 'signalling' given by these catalysts. Thus, the so-called niches (Thaler, 2009) given by fiscal policy (to some extent, also by monetary policy) as well as by the regulation of the functioning of the financial market are, from a conceptual point of view, catalysts – for example, 10% reduction of the local payment tax, if it is paid in full within the first quarter of the fiscal year in question, changes the preference (behaviour) in the sense of stimulating the full payment of the tax within the specified period. We could say, in an attempt to generalize this punctual example, that the preference for repetitive small payments has changed to the preference for single full payments. Of course, the functioning of the financial market is much more subtle than the example we have just provided, but the essence is the same: the catalyst has the potential to change the preference, which thus adapts to the market. Moreover, like automatic stabilizers, which we have already discussed in Chapter 1, catalysts, if correctly and, as far as possible, exhaustively identified and modelled, can be important predictors that can underlie the choice of strategies that can *beat* the market.[223]

Cycles and hypercycles

The concepts of cycle and hypercycle (the second concept is introduced in the specialty literature – more precisely, in pre-biotic modelling of the origin and evolution of life, especially in modelling the formation of DNA and RNA molecules – by Manfred Eigen (1979)) are also of interest from the perspective of adaptive preference and, especially, of the logical modelling of its phenomenology. Hypercycle refers to self-replication and self-catalysis,[224] respectively. Therefore, within the genus called catalysts (which generate catalytic processes), there is a species called auto-catalysts (which generate self-catalytic processes). Self-catalysis is, from the point of view of systems theory (more precisely, from a cybernetic perspective), a positive feedback – a process oriented in one direction (and in a sense of that direction) will be stimulated to continue on the path which is located. Bringing the issue to the case of adaptive preference, we can say that self-catalysis refers to increasing the probability with which the preference in question 'chooses' a certain trading strategy.[225]

The hypercycle of interest for our study[226] is defined as a connected set of cycles of self-replication of preference and of trading strategy.[227] It is obvious that, in the phenomenology of the financial market and preference, the processes of self-replication are ideal 'hosts' for the concept of hypercycle.[228] From a technical point of view, the hypercycle is formalizable by means of an ordinary differential equation (ODE).[229] As the adaptive preference can be formalized by the same mathematical operator, the possibility of using the hypercycle in modelling (including quantitative) of the adaptive preference is as attractive as possible and (we appreciate) productive.

In economics, there are only sporadic approaches and more by formal analogy with the differential equation proposed by Eigen (Curry, 1985), without a specific theorizing for economic phenomena and processes (Watts & Binder, 2012).

Feedback

In almost the entire previous discussion, more or less, explicitly or implicitly, in one form or another, the concept of feedback was evoked. This concept is the central concept (founder, even) of cybernetics, a discipline that defines itself, in a crude way, as the science of feedback, an interdisciplinary science, bordering on biology, automation, and systems theory and based, of course, massively, on logic and mathematics.

The concept of feedback defines, as its name suggests, the reverse reaction in a system.[230] This means that feedback refers to a system and not to the interaction between that system and the environment (which obviously includes other systems – in fact, the environment itself can be considered/modelled as a single system, within certain agreed limits).[231] More precisely, feedback is a reaction from the output of a system to its own input in the next operating cycle of that system, which means that the feedback falls within the self-control reactions. Well-executed simulations can lead to the introduction with anticipation, in input, of the correction that could come from one's own output, but the rule is that this correction is done dynamically as the operating cycles of the system in question proceed.

The literature on feedback is huge, and the concept has become a 'public good' in scientific research in all fields. As a result, we will not develop this topic too much from the perspective of this study, given that feedback is not our research topic but is only an ingredient (very important, by the way) in examining the problem of logical modelling of adaptive preference. We will mention only the main features of the concept in question.

The most important aspect is that the feedback refers to the system, not to the interaction of the system with the environment, as we have already specified; in the case discussed in the study, it refers to the adaptive preference (as an adaptant) – of course, regarding the financial market, there is a feedback related to it (but which, symmetrically, is not related to the adaptive preference).

Feedback has two conceptual species: (a) negative feedback – the reverse reaction that ensures the stability of the system;[232] and (b) positive feedback – the reverse reaction that generates the escalation on the system trajectory.

Negative feedback:[233] this type of feedback ensures an output (and a variation of the output) at a value (and over a range) previously established and which, from the perspective of the interest of the system in question, must be preserved.

Let's note by x_t the size of the input at time t, by y_t the size of the output at time t, by $\varnothing y_t$ the acceptable deviation (acceptable gap) of the output from the desirable (normed) size of the output ($\Delta y_t = |y_t - \tilde{y}_t|$) (where $\tilde{y}_t$ is the normed size of the output. *Nota bene*: the deviation of the output must be considered in in its absolute value, so as to correct both the negative and the positive deviations from the normative value), with GA a gap analyser and with BB the system considered as black box (i.e., a system in which the analytical way in which the input is transformed into output is not of interest but only matters that there is a transformation operator – a mathematical operator – which ensures this transformation), that is, $y_t = f(x_t, BB)$; note that the 'variable' BB is a constant.

With these notations, the operation of the negative feedback can be modelled as in Figure 2.12 (*Nota bene*: the sign $\uparrow$ indicates the application of the gap value to the new input in direct proportion, and the sign $\downarrow$ implies the application of the gap value, inversely proportional).

Regarding the positive feedback, we have to give up the calculation of the gap in its absolute value, that is, we will have: $\Delta y_t = |y_t - \tilde{y}_t|$; with this notation, the function of the feedback becomes that of Figure 2.13.

A simple (purely illustrative) formalism of negative (reactive) feedback is as follows:

- based on the aforementioned notations, we will consider two moments, t and $t+1$;
- be BB a transformation operator that consists of a coefficien of multiplying the input transformed into output (multiplication can refer to monetary value – what economists call added value); we denote this multiplication

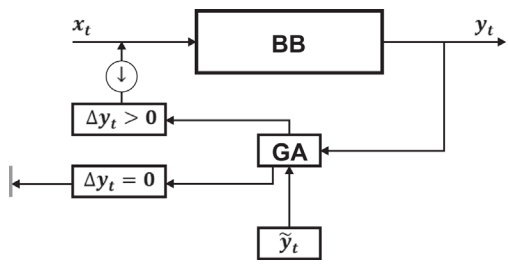

Figure 2.12 Abstract functioning of the negative feedback.

Source: Authors.

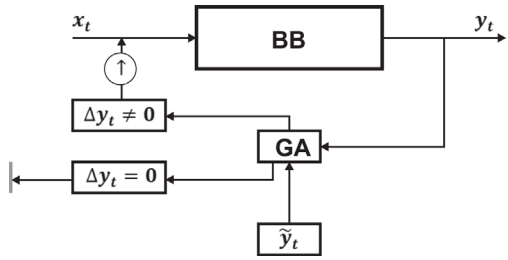

Figure 2.13 Abstract functioning of the positive feedback.
Source: Authors.

coefficien by k ($k > 1$); we will consider that the transformation operator is constant (of course, a model can be built in which this operator depends either on time or on its own operation);

- then $y_t = f(x_t, BB) \rightarrow y_t = k \cdot x_t$;
- be $\tilde{y}_t = N$ (normed outcome value), and N can be both constant and dependent on time or another significant parameter (for simplification, we consider it constant);
- then $\Delta y_t = y_t - \tilde{y}_t = y_t - N$; on the assumption that $N \uparrow y_t$, we have

  $y_{t+1} = k \cdot (x_{t+1} + y_t - N) \rightarrow y_{t+1} = k \cdot x_{t+1} + \delta_{t+1}$, where δ_{t+1} is the reactive feedback correction ($\delta_{t+1} = k \cdot \Delta y_t$).

When the gap between the normed output and the effective output can be anticipated, the correction can be introduced into the input before the start of the functioning cycle of the system in question: this anticipative feedback is called *feedforward*. Therefore, while 'standard' feedback is reactive, feedforward is anticipative. However, both are closed – they are dependent on the system's own output. Depending on the needs of the analysis (or of the command and control), the feedback can be synchronous or asynchronous (the synchronism can be programmed in the actual device of the feedback) (Fedorenko, 1979).

Outline of a logical model of adaptive preference

Generalities and assumptions

GENERALITIES REGARDING THE LOGICAL MODEL

- it is a model of adaptive preference, of qualitative type;
- it integrates the three classes of principles discussed in the preliminaries, namely, the six explicit principles;

- it is co-evolutionarily oriented, which also involves the adaptive (financial) market, discussed by Lo; therefore, although modelling is preferably targeted, it can only be examined in tandem with the environment (which, in AMH's view, is the financial market itself);
- it constitutes the logical basis for the quantitative modelling that will be proposed in Chapter 3;
- it is a behavioural model, in which the information-behaviour relationship is biunivocal oriented causally/conditionally and not just univocally (as both EMH and AMH do, despite the statement of the latest model regarding market selection on strategies trading);
- our attempt refers to, therefore, not about a selection function exercised by market over trading strategies (which is reduced, conceptually and methodologically, to a selection within a population-type evolution)[234] but to such a selection function that the market exercises over the preference, which thus becomes, so, an adaptive preference;[235]
- in our opinion, there is a certain compartmentalization[236] in the co-evolution of adaptive preference – financial market, namely: (a) a 'first line' or *front office* compartment: regarding the *informational* impact on the choice (or variation in the choice) of the trading strategy; (b) a 'second line' or *back office* compartment: referring to the *behavioural* impact of the choice (or variation in the choice) of strategy on the choice (or variation in the choice) of preference. Of course, the preference-strategy system has its own feedback, stabilizers, synergies, catalysts (or self-catalysts), and selections. All of these are of interest in describing the mechanism by which adaptive preference integrates pairwise information-behaviour, as for EMH or AMH, price or other variables or parameters that describe the functionality of the financial market is of interest in integrating information.

ASSUMPTIONS ABOUT THE LOGICAL MODEL

- the financial market is a *friction market*, that is, there are transaction costs (both for the acquisition of information and for risk-taking);
- the financial market is *not informational transparent* about any type of information, either outside – public or private – or internal, more precisely, inside;
- the financial market is *behaviourally transparent*, that is, the memetic impulse is 'free';
- economic behaviour is standardized from four points of view:

    1 the public institutional framework;
    2 the system of beliefs/habits and preferences;
    3 (limited) models of rationality;
    4 experiences/memory (past);

- the criterion for changing the trading strategy or preference is the criterion of economic survival (*second-best* type);
- the selection of the trading strategy or preference is a self-catalytic process within the financial market (equivalent: the financial market is the species, and the trading strategy is the individual – this idea will be developed later);
- the environment of the species (i.e., the financial market) is the non-finan cial economic environment and the institutional environment; as a result, co-evolution does not occur between the individual (trading strategy) and the species (financial market) but between the individual and the 'species' environment;[237]
- the financial market, as a species, is self-organizing (equivalent: autopoietic).

Synoptic

The logical model of adaptive preference can be represented, in a general (so simplified) form as in Figure 2.14.

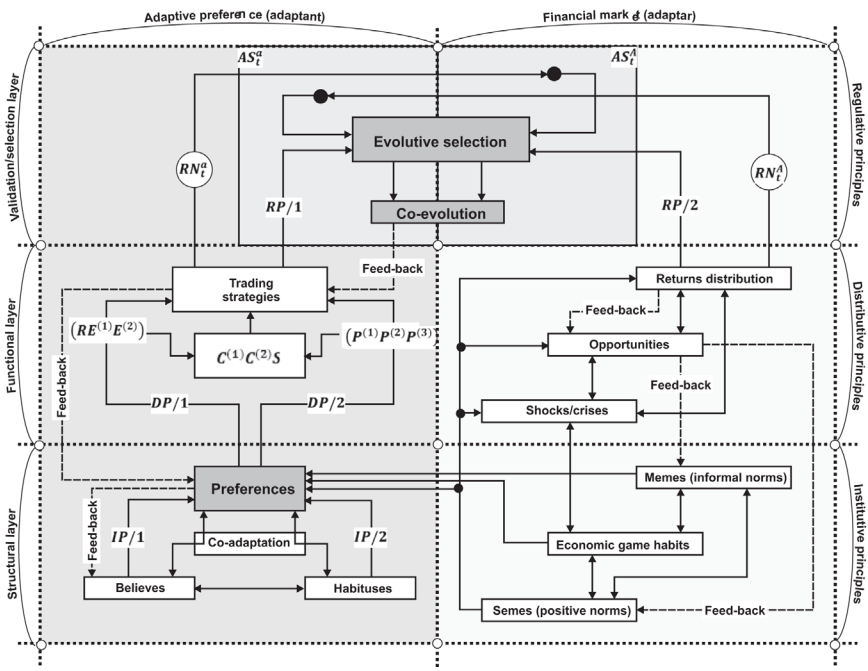

Figure 2.14 An outline of the logical model of adaptive preference.

Source: Authors.

Short discussion

THE STRUCTURE OF THE FINANCIAL MARKET

The financial market has a three-party structure: the habits of economic game, the memetic structure, and the semetic structure:

1 *usual practices of the economic game*: refer to the experience that the market (in fact, of course, market players – agencies that trade financial assets) has gained over time (e.g., the calendar effect in BMH is part of the usual practices of the economic game). Usual practices of the economic game can be formal (e.g., economic contracts, such as the option contract) or informal (e.g., price discrimination in different markets). Being a structural component of the financial market, usual practices are the main generators of the functions that the economic game (either cooperation or competition) generates. Usual practices of economic game are generally informal norms, although they often materialize in formal norms, such as contracts;
2 *memetic structure*: it refers to the transfer, either vertically (i.e., in time) or horizontally (i.e., in space), of the ways of achieving the economic game. Meme (Dawkins, 2018) is a psychological 'device' that ensures the contagion and imitation (or, in competitive cases, only mimicry) of successful or seemingly successful behaviours. For example, the *herd effect* is an effect of this memetic structure (or memetic potential) of the (financial) market. The (correct) emphasis of behaviourism on the heuristic decision (trial and error) tries to precisely capture the memetic structure of real economic behaviour. Memes are informal, contingent norms. However, an intelligent legislator, who carefully monitors memetic behaviours, will be able to notify the need to formalize memes – as we have shown in Chapter 1, compliance and violation of memes are signals to the legislator on the usefulness of regulating/deregulating them;
3 *semetic structure*: refers to the formal positive regulatory framework (law) that is in force in the environment in which the financial market is functioning and, therefore, also the economic agent. Like the other two structural components of the financial market, the semetic structure works ambivalently: on the one hand, it is a set of constraints on the design of trading strategies, and on the other hand, it is a source of opportunities for transactions. Depending on the actual functioning of the financial market, constraints and opportunities can pass one into the other – for example, constraints in one trading area may open/signal opportunities in another trading area.[238] As in the case of memes, the smart legislator monitors the functioning of the semes and, depending on the degree and manner in which they are respected/violated, introduces the necessary changes, from minor adjustments to deregulation.[239] The most frequent mutual transition from one to another is, of course, in the case of the meme-seme pair.[240]

THE RECIPROCAL POSITION OF ADAPTIVE PREFERENCE AND FINANCIAL MARKET

This issue is of the utmost importance and relevance to the subject of the present study. Its elucidation also counts from the perspective of evaluating the process of co-evolution, in connection with which there are enough ambiguities in the literature. We will discuss the following aspects: (a) the individual-species relationship in the case of the preference-financial market pair. (b) the concept of quasi-species on the financial market,[241] and (c) the concept of co-evolution on the financial market.

The *individual-species* relationship on the financial market is not unambiguous, including at the conceptual level. The main ideas in this area could be the following:

- like any economic market, the financial market represents the inter-dependent set of financial transactions (acts/abstentions of exchange of financial assets);
- each financial transaction can be considered, from a theoretical point of view, an individual or, in other words (having the same meaning), an individual occurrence;
- therefore, the species – that is, the financial market – is made up of individuals – that is, exactly financial transactions or, on a more aggregate level, trading strategies;[242]
- as financial transactions can be put under the label of the trading strategies which, in turn, can be put under the label of the (adaptive) preference, it turns out that individuals who form, in a dynamically way, the financial market, can, alternatively, be of four types: (a) physical individuals,[243] (b) punctual transactions, (c) trading strategies, and (d) (adaptive) preferences;
- therefore, we have individuals and species between the adaptive preference (which seems to be the widest category of individual in the species) and the financial market (which seems to be the species for adaptive preference); it cannot take place as a process of co-evolution but at most a process of co-adaptation.

The *concept of quasi-species* comes from biology or rather from the pre-biotic stage of nature (or life) (Eigen & Schuster, 1979). The significan e of this concept is, however, also relevant to the functioning of the financial market and, in this context, to its adaptive preference and functioning. Therefore, at the beginning, it is interesting to present the original concept of quasi-species. In this regard, we present the following considerations:

- quasi-species means a species in which there is not a single genotype that is copied in the replication process more or less accurately (having a relatively low mutation rate) but contains several genotypes (*a cloud of genotypes*), with a high mutation rate; this means that the reproduction of individuals

from the quasi-species does not depend on a single genotype (in our case, on a single preference) but on the set of competing preferences between them;
- the quasi-species can lead, in time, to a single species, through the so-called population selection, that is, through the predominance, at a given moment, of the replication of one of the genomes or, as the case may be, to several species;[244]
- both competition and cooperation in the financial market (i.e., between trading strategies and, ultimately, between adaptive preferences) allow (or even advertise) the existence of quasi-species, that is of *cloud*-type financial markets. Therefore modelling, both logically and quantitatively, the functioning of adaptive preference must seriously consider the concept of quasi-species or, through a terminological adaptation, the concept of *quasi-financial market*.

The *concept of co-evolution*: the general aspects of the concept of co-evolution have already been presented in Chapter 1, so here we will add only the particular aspects generated by the consideration of the relationship between preference and financial market or, equivalent, between individual and species. These particular aspects are, in our opinion, the following:

- co-evolution means a tandem with an evolution, that is, based on mutual interactions (*Nota bene*: based on the conditions of reaction norms – see section "Reaction norms") *between two species*. We emphasize, therefore, the idea that we have co-evolution between two species, not between the individual and the environment;
- of course, the just-mentioned concept of co-evolution – as a process between two species – is adjudicated as such by the dominant specialty literature; this does not mean that we cannot define (or accept) the co-evolution between the individual and the environment (in our case, between preference and the financial market), but this new meaning requires (must contain) sufficien explanations of rigour;
- in our opinion, the concept of co-evolution should not be forced (in a Procrustean way) so as to include the individual-species relationship. In this regard, we consider that the following clarifications are of interest:
    - the financial market is the species (of course, with its construction phases, in which it can be, temporally or spatially, but for limited periods of time, a quasi-species, as we shown earlier);
    - individuals of the species are trading strategies;
    - trading strategies have, among the causal/conditional factors, preferences;
    - the environment in which the species evolves is the social environment that includes, in general, (a) the real economic environment (non-fina - cial), (b) the formal normative environment (semetic), (c) the informal

normative environment (memetic), and (d) economic memory (experiences, traditions, customs, etc.).

- the selection that the environment makes on individuals refers to the selection made on trading strategies; changing the share of these trading strategies will change the species (i.e., the financial market), thus leading to a population-type evolution.[245]

THE CRITERION FOR VALIDATING THE TRADING STRATEGY

Here we will discuss the criterion that ensures the cumulative directed selection (or, alternatively, as we said earlier, the punctuated directed selection[246]). It should be noted that, although the choice of trading strategy is equally subject to the three components of the modal filter (see section "Adaptive preference and adaptive market"), on the one hand, and preference, on the other hand, the evaluation of the result of the application of that strategy is predominant from a rational perspective. Therefore, there is no doubt that the agent will judge the success or failure of its trading strategy on a relatively objective basis – for example, in terms of the return obtained, adjusted to the risk assumed (and paid). We will accept, therefore, as a criterion for evaluating (ex post) a trading strategy, the utility (constructed in a somewhat different way from the standard substantive utility) brought by that strategy. This way of posing the problem leads to two very important results:

1 *self-organization*: this process (explained earlier) occurs at the level of the agent, that is, at the level of the individual population who represents the denoted concept of trading strategy, being led by the individual himself. Self-organization has obvious semantic similarities to the concept of co- (or self-) adaptation. The context in which self-organization takes place is that of competition with other individuals (i.e., with other trading strategies) and of cooperation with other such individuals. Self-organization has no selective effects, although small adjustments (below the selection threshold) may increase the probability that the trading strategy in question will be subject to environmental selection. This variation in probability is relatively predictable, as the agent will make adjustments (which are made rationally) towards further exploitation of the occasionally occupied or accessed niche – or this may increase the specialization of the strategy, which, as mentioned in section "Selection and self-organization/autopoieticity", increases the vulnerability of the strategy in question. The increase in vulnerability can, of course, be expressed in terms of *a posteriori* Bayesian probability (in no case as a frequential probability);[247]
2 *cumulative targeted selection*: this process also takes place at the level of the agent or the individual (in the sense used in this study), but this time, the process in question is environmentally driven. Those trading strategies that failed (either absolutely did not bring profit above the market average

> or relatively did not bring profit to (over) cover transaction expenses with information gathering and risk-taking) will no longer be used in subsequent trading episodes. The agent's reason for giving up these trading strategies can be seen, equivalently, as a selection that the environment makes about the fitness associated with these trading strategies – the environment rejects the selection of those trading strategies with insufficien suitable fitness [248] Obviously, the fitness of a trading strategy will depend on all three components of the financial market structure (see Figure 2.14), which are structures introduced by what we have called the environment of the species the fina - cial market.

In principle, therefore, as in the biological case, the criterion for validating the trading strategy will be its fitness (the size of this fitness) in relation to the environment in which the species called the financial market is functioning. But, as we have mentioned (see note 138), the concept of fitness will be examined, in all its complexity, later.

THE INFORMATION-BEHAVIOUR RELATIONSHIP

This issue refers to the research topic that will be addressed (this time in a strongly quantitative manner) in Part 2 of Chapter 3. Since on that occasion the subject in question will 'enjoy' a thorough examination, here we will make only a few general considerations.

It is entirely admissible to assume that information is the most important *explicit* factor (or variable) in the financial economic game that interests us here. In fact, all (let's accept, this time) three models of the financial market or, more precisely, of the functioning of the financial economy[249] – BMH, EMH, AMH – consider information as one of the channels through which the financial trading decision is the designed/chosen one. But there are notable differences between the three models in terms of the effective role given to information. Of course, the impulse to synoptically represent the distinctions between the three models regarding the place given to (explicit) information is irresistible (Figure 2.15).

The emphasis on the *explicit* predicate means that there are *implicit* factors or variables that can be just as important (according to some authors, even more important), both in logical and chronological orders (Froese et al., 2012). The most 'qualified for such implicit variable is behaviour.

As already shown in section "Information and behaviour", the information does not only induce (cause/condition) the behaviour. One of the variables (considered a constant parameter in EMH) that complements information is the preference which, as it is easy to see, does not depend on information (neither current nor past) but crucially depends on the agent's belief. But a third variable of interest here is the behaviour that does not have to be (necessarily) caused or conditioned informationally. For example, habit (or its 'relative', from which it is difficul to distinguish, the imitation occasioned by memetism) is not conditioned

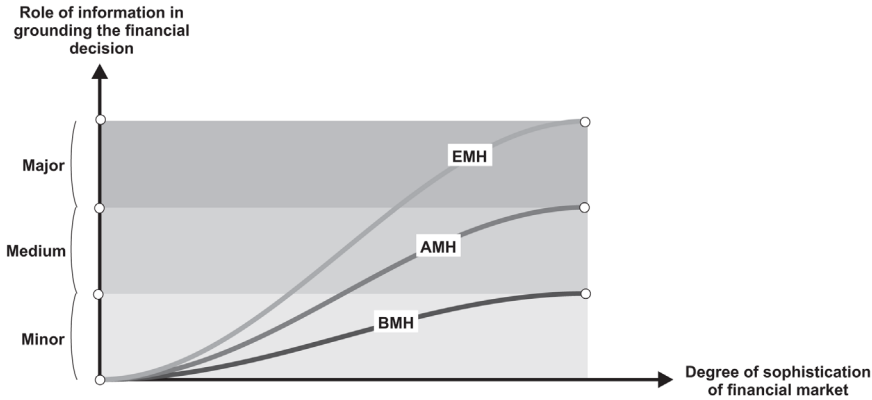

Figure 2.15 The role of explicit information in the three distinct models of the financial market.

Source: Authors.

informationally. Of course, it could be objected here that both habit and memetism are also replicated on an informational basis, but it should be observed that (even if it is so, although it is not entirely so) the information in question is not ordinary information which refers to the variables of the financi l market but one of a different quality, different nature, and different significance in the generation of behaviour. We conclude, therefore (but we will return with the in-depth analysis in Chapter 3), that the behaviour in objectifying (designing, choosing, and operationalizing) a trading strategy can be relatively independent of explicit information and, especially, of explicit information targeting specific variables of the financial market.

GENOTYPE AND PHENOTYPE ON THE FINANCIAL MARKET

The theory proposed by Lo suggests that the financial market and the trading strategies in this market enter into a selection process that the market exercises over the trading strategy. The idea is obviously similar to the one advanced by Nelson and Winter (1985) regarding the microeconomic evolutionism, more precisely, of the firm (either financial or non-financial) – in the case of Nelson and Winter, the economic market (wider than the financial market) selects what they call *routine*, that is, a way in which the company achieves its objectives, including both technological and financial or managerial aspects.[250] It should be noted that, both for Lo and for Nelson and Winter, the market is the court that executes the selection, so it is the environment for the trading strategy (in the case of Lo) and for the routine (in the case of Nelson and Winter). In this context, we will make some

considerations regarding the way in which the logical model of adaptive preference, presented earlier, addresses these evolutionary aspects.

Lo talks about the selection that the financial market makes on the trading strategy. It is true that the game (either competition or cooperation) that takes place on the financial market makes, in the end, a trading strategy or another to be replicated (if it was successful) or rejected (if it failed), what represents the content of the targeted selection itself (whether the selection is gradual/cumulative or explosive/punctuated). But this *prima facie* evidence hides a trap: the species disappears. Indeed, if the trading strategy is the individual (as Lo seems to think), then we do not have a species that evolves behind selection.[251]

Based on the previous reasoning, we have proposed, in our logical model of adaptive preference, that the financial market represents the species for the trading strategy (representing the individual) and the environment for the species, as well as for the individual, be the rest of the economic, social, and institutional environment. We consider that such a conceptual representation is more apt to contain an evolutionary process that, in principle, integrates, as a module, the hypothesis of Lo's adaptive market.

In this context, the concept of co-evolution, which 'requires' two species or, equivalently, one species and one environment, regains its standard content: one species is the financial market (with its individuals, trading strategies), and another species is the non-financial environment of the economic system.

As any evolutionary process needs the two components still introduced by the original Darwinism: mutation and selection, in the conclusion of the present study, we will formulate some clarifications in this matter:

- if the trading strategy is the one that supports the selection process, so if it is the individual subject to selection, then, from a conceptual point of view, the trading strategy is the phenotype;
- but the mutation affects the genotype. What is the genotype in this case? In our opinion, the genotype is the preference (which we will consider in its version of adaptive preference).[252] Therefore, the mutation, as shown in Figure 2.16, which can be both inside and outside, is exercised over the preference which, like any genotype, subsequently generates the phenotype;
- this is the 'point' at which the impact of the preference on the trading strategy occurs, that is, new information, resulting from the mutation, is induced regarding the development of the corresponding phenotype;
- in the financial field (economic, social), the mutation is no longer exclusively random; it also acquires a deliberative component (project or discretionary decision).[253] The exact mix between the random and the deliberate component in the formation of the mutation is difficul to estimate; it can be, at most, the object of some hypotheses or conjectures;
- in this context, both self-organization and co-adaptation are processes that take place at the level of the phenotype, without suffering a significant impact from the environment, and the latter will act, especially on the selection (in a positive or negative sense, as the case may be) to the trading strategy which

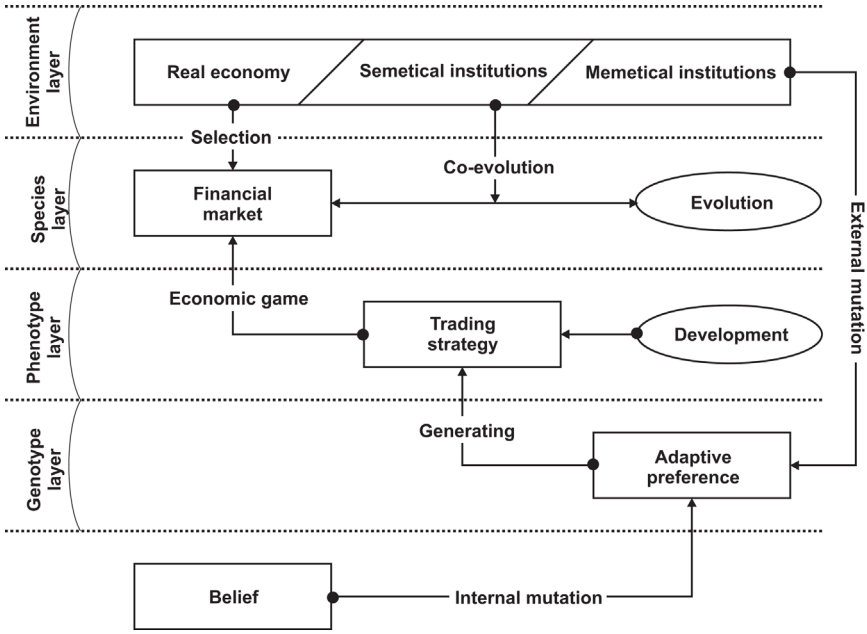

Figure 2.16 Genotype, phenotype, and evolution on the financial market.

Source: Authors.

leads to the evolution – of course, to the evolution of the species, that is, of the financial market, as previously shown.

The evolutionary aspects from the perspective of the genotype and the phenotype on the financial market are suggested graphically in Figure 2.16.

A short Kuhn-ian examination of EMH and AMH

Preliminaries

Many authors use the term *paradigm* in a rather non-rigorous manner, as a label applied to a specific modal way of achieving a result, developing a cognitive process, or making a decision. Some analysts apply the term *paradigm* to all prominent financial market models without providing adequate justification or theoretical foundation. The purpose of this section is to examine the AMH and EMH through the lens of the Kuhn-ian paradigm. The argument is that while the Kuhn-ian paradigm is the most well-known paradigm concept, it is a cognitive paradigm rather than a praxiological one, as financial market models aspire to be. To address this shortcoming, we propose a matrix of evaluation of a behavioural

pattern *qua* paradigm using the logical analysis based on the structural, functional, and regulative features of a praxiological paradigm, based on Kuhn's suggestions but departing significantly from them. The conceptual apparatus is applied to the EMH and the AMH, and the results show that EMH is a (praxiological) paradigm, but AMH is not because it lacks the regulative condition/principle. This result is significant because it may lead scholars interested in this topic to further develop the AMH pattern to bring it to the status of a real (perhaps non-Kuhn-ian) paradigm on/of the financial market.

General background

The concept of paradigm

Generally, a paradigm is a model of rationality, regardless of its purpose (cognitive, practical, or praxiological).[254] We consider that a paradigm, in the most abstract way,[255] has a structure based on four components (Dinga, 2020):

1 *value* (**V**): the value addresses the founding of the paradigm's finalit . For example, the complete rationality (or hyper-rationality);
2 *nucleus* (**N**): the nucleus addresses the prime (primitive, fundamental) principle of paradigm. For example, the selfishness [256]
3 *function* (**F**): the function addresses the finalit [257] of paradigm (in fact, the purpose of actors using that paradigm). For example, the minimizing of the opportunity cost in neoclassical economic theory;
4 *logic* (**L**): the logic addresses the principles of rationalization[258] of paradigm. For example, the methodological individualism.

The four structural components of the paradigm must be consistent two by two and convergent to function (F). Therefore, for any particular paradigm that is analysed, the two 'C' (consistency and convergence) must be verified in order to get a concluding answer to the question if it is really a paradigm.

Figure 2.17 describes the general structure and functioning of an abstract paradigm, so it is valid for any kind of paradigms, understood as a Value-Nucleus-Function-Logic (VNFL) model.

The value of paradigm generates its nucleus, which, in turn, generates its function, which, finall , built up its logic. So, we order lexicographically the four structural components of a paradigm. This logical dependence among the components does not allow us to view the VNFL model of paradigm as an axiomatic model.

Validating the paradigm conserves its justification, which, in turn, verifies its explanation, which, finall , could falsify (in the Popper-ian sense) its grounding.

In fact, three distinct kinds of paradigms can exist. This typology is based on the distinction among three fundamental sorts of human activities, as they result from the general relationship between subject and object: (i) *theoretical* activity is given by the object-object (i.e., physics or biology) relationship; (ii) *praxiological*

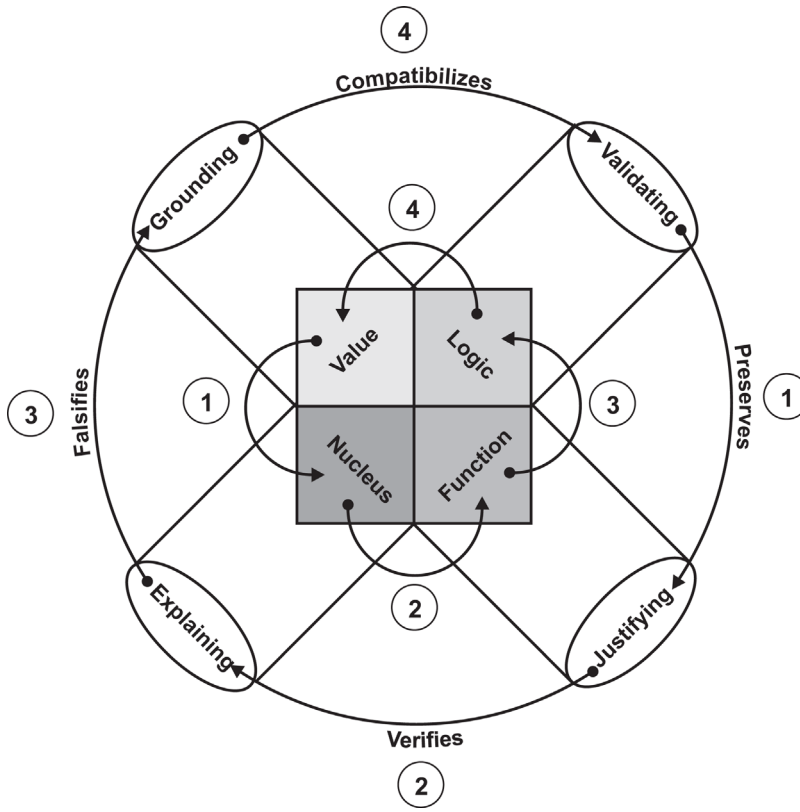

Figure 2.17 The structure and functioning of the general (i.e., praxiological) paradigm.
Source: Authors.

activity is given by the subject-object (i.e., economics) relationship; (iii) *practical* activity is given by the subject-subject (i.e., politics or religion) relationship.[259] Based on the typology of human activity, there are three categories of paradigms.

1 for theoretical activity: *cognitive* (gnoseological) paradigms.[260] The cognitive paradigm maintains only two components of the general paradigm: nucleus and logic (so, it is a NL paradigm), because the cognitive paradigm neither needs a function (the internal logic of knowledge, e.g., does not provide any function – knowledge is something free) nor does it have to be based on a value (i.e., the knowledge must not allow value judgements);
2 for praxiological activity: *praxiological* (actional) paradigms (as it will be developed further). The praxiological paradigm holds all components of the general paradigm, so it is a complete paradigm, or a generative one (it is a VNFL paradigm). Logically, the praxiological paradigm is the genus for the

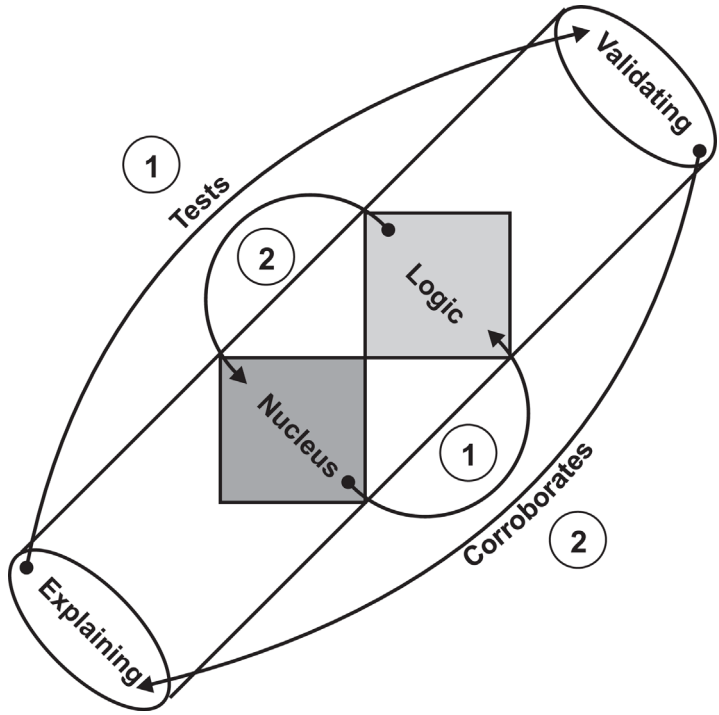

Figure 2.18 The structure and functioning of the cognitive paradigm.
Source: Authors.

species cognitive and comprehensive, respectively, although it is, at the same time, its own species;

3 for practical activity: *comprehensive* (hermeneutic) paradigms. The comprehensive paradigm holds three of four components of the general paradigm: value, nucleus, and logic (so, it is a VNL paradigm), because the comprehensive paradigm does not need the function (understanding the world and the self are *sine qua non* commands of the cultural subject).

Figures 2.18 and 2.19 synoptically illustrate the cognitive and comprehensive, respectively, kinds of paradigms by using the general (abstract) model in Figure 2.17.

The most well-known concept of paradigm is the Kuhn-ian paradigm, which is, however, of cognitive type, as Figure 2.18 exhibits, so further we will consider only Kuhn-ian suggestions (Kuhn, 2012) which seem to be of general application, so they could be appropriate for discussing the praxiological paradigm.

Therefore, the logical basis of getting the purpose of paper will be provided by the complete model of paradigm, that is, by the praxiological (or, equivalently, actional) one.

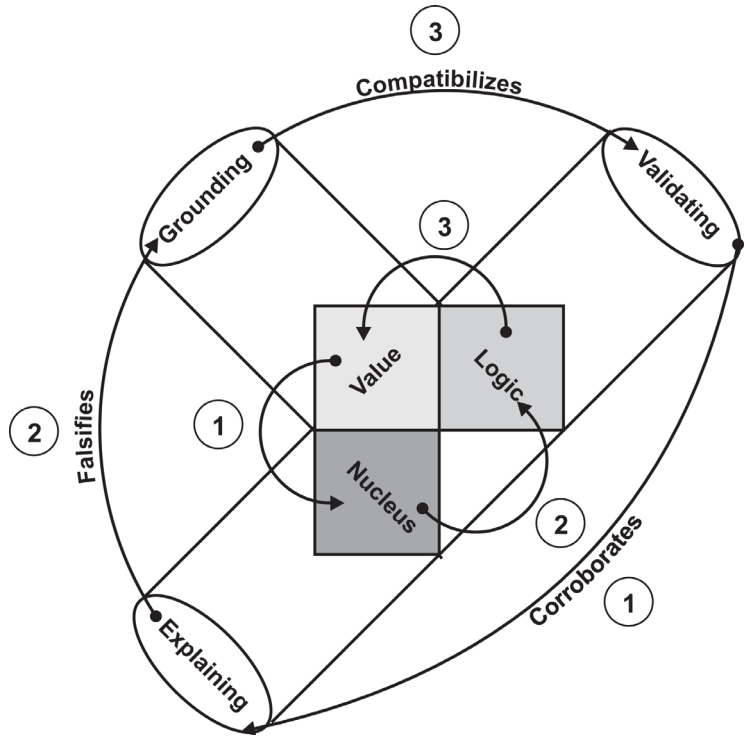

Figure 2.19 The structure and functioning of the comprehensive paradigm.
Source: Authors.

On the criteria to assess a logical model qua *paradigm*

We propose three criteria/conditions to be verified by a logical model, no matter its nature, so that the model be qualified *qua* paradigm: (i) the *institutive/structural* criterion (or condition): the model concerned must verify the four structural components of a paradigm, as they are mentioned in section "Preliminaries", that is, for the model concerned, to be identified and non-ambiguously described those four components; (ii) the *conservative/homeostatic* criterion (or condition): the model examined must maintain its identity (i.e., its structure) in a sustainable way under the theoretical critics and/or empirical refutations; (iii) the *regulative*/*homeorhesic* criterion (or condition): the model in case must hold principles, devices, and/or internal mechanisms, to maintain itself on its trajectory, although accepting dynamic adjustments. These criteria will be analyzed, where they will be applied on both EMH and AMH.

BRIEFLY ON RELATED LITERATURE

The concept of paradigm is used in the literature regarding the financial market functioning in four meanings: (a) as a synonym for a given way, no matter how simple or sophisticated, followed in no matter what demarche, either cognitive or instrumental; (b) trying to identify the so-called Kuhn-ian moment[261] when the anomalies become overwhelming; (c) as a reflection of the well-known Kuhn-ian concept of paradigm; (d) as assimilating methods, instruments, techniques, and even regulatory public policies with paradigms. We briefly examine next each of these approaches.

Many authors use the term *paradigm* in a rather non-rigorous manner, as a label put on a given modal way to get a result, to develop a cognitive process, or to take a decision. Some of the analysts give the name of paradigm to all the three (most) prominent models of financial markets,[262] that is, EMH, BMH, and AMH, without providing sufficien reasons or theoretical foundation to proceed this way. Generally, EMH is considered *ab initio* as being a paradigm, and only the other two models remain to be examined as candidates for new paradigms, as alternatives to or integrators of EMH. To getting such alternatives, all approaches start from the so-called anomalies[263] accounted by EMH. It must be said that Kuhn had in his view a cognitive demarche, not a praxiological one, as the financial markets model aspires to be. Of course, the transversal import of concepts among scientific and/or praxiological areas is undoubtedly useful (e.g., based on analogies), but it is needed to have a look, at the same time, on the context in which the imported concepts or terms are genuinely created and originally used. For we have at our disposition, for example, the term *pattern* that can be well and easily adapted to particular cases of modelling, instead of using the pretentious concept of paradigm. Some researchers even think that an extension of EMH in order to 'digest' some anomalies could constitute a new paradigm (Fender, 2020). Although it is true that Kuhn's solution to solve the anomalies (accumulated over a fixed threshold)[264] is a new paradigm, any anomaly (or any quantity of anomalies) must not or cannot lead to a new paradigm – for a while, the anomalies are tolerated (are swept under the carpet), and a new paradigm is required after anomalies (qualitatively or quantitatively) pass beyond a threshold[265] which irremediably alters the current paradigm (or, in Kuhn's terminology, alters the normal science[266]). What we want to say is that the set of anomalies arisen must be examined under a strict and rigorous methodology strongly assigned to a standard logical concept of paradigm (as it proceeds here) to see if the current paradigm is really incapable to explain them. To be mentioned that some anomalies occur as a result of data manipulation (because of either incompetence or interest), and other anomalies are reported only to combat EMH (Malkiel, 2003).

Some authors, more scrupulous, that's right, try to connect their contributions in a tighter way either to the general philosophy of science or to the genuine concept of the paradigm established by Kuhn. These approaches can be characterized as follows:

- generally, they are focused on the anomalies relative to EMH, although, in our opinion,[267] the anomalies are not important here but the amount of researchers

or practitioners, after the case, in the given scientific or praxiological community who share the normal science or practice inside of a paradigm. In other words, the threshold which must be reached rather refers to the majority (or, at least, a critical mass of researchers/practitioners) than to the anomalies as such;

- linked to the previous feature, these kinds of approaches target the so-called Kuhn's momentum, that is, the time (or, in fact, the period) in which the new paradigm begins to replace the old paradigm. The main signal for such a replacement consists in providing solutions (i.e., explanations for the anomalies associated with the old paradigm (Lo, 2019; Fender, 2020) which are inaccessible for the old paradigm or do better such explanations;
- regarding the identification of the new paradigm in course of replacing the old one, there are no studies, in our opinion, which succeeded in such an objective. The issue is overly complicated from epistemological point of view: (i) firstl , the new paradigm must be born without the old paradigm, so be apt, by gradually contaminating the researchers/practitioners inside the old paradigm, to conquer its territory; (ii) secondly, this contamination should not reach any anomaly but, perhaps, some anomalies (or even a single one) which could be named *anomalia crucis*. The concept of *anomalia crucis* (equivalent, as its function, with the *experimentum crucis* in the matter of factual falsification) is not (yet) discussed in the specialty literature. In our opinion, it is largely persisting a confusion among scholars regarding the Kuhn's momentum – we believe, by following Kuhn himself, that such a momentum addresses the critical mass of researchers/practitioners inside a given paradigm who are convinced that an *anomalia crucis* has already been established for the old paradigm.[268]

Next we shall discuss the so-called theory of reflexivity (focused on financial market) proposed by a 'failed philosopher' and 'successful speculator' – we are talking about George Soros, who has characterized himself as such (Soros, 2009). In fact, Soros confirms his own evaluation on himself: the theory of reflexivity is far from to be a theory; it is useless to add that, in the matter of reflexivity or self-reflexivit , the general philosophy already reached levels incomparably more deep and subtle. We could mention, however, some consequences of that 'theory' (strictly) regarding the financial market functioning:

- financial market is never well working but is always wrong, because of the incompleteness of human's knowledge on the reality;
- reflexivity is, basically, consisting in a two-way feedback: one among individuals, and other among events (facts); this two-way feedback generates uncertainty among subjects as well as indetermination among events;
- one of the structural difficultie to understand the reality (namely, the fina - cial market) comes from the fact that individuals are not only observers but

also participants (practitioners) in the market functioning, that is, a component of the reality concerned;[269]
- for the economic field, the theory of reflexivity and the theory of equilibrium are incompatible;
- individuals do not act towards their own interest but rather towards their perception on own interest;[270]
- (one of the most interesting sentence based on the theory of reflexivity) the price (or its change) can influence the fundamentals of the concerned price, that is, they can influence the value [271]
- the theory of reflexivity allows the so-called fertile fallacies, which are common for any field and any culture in the history;
- the history is important and relevant for understanding (at least, as aspiration) the functioning of financial market;
- and, of course, the theory of reflexivity constitutes, in Soros's view, a new paradigm about the financial market (and even la ger, for the entire society).

Finally, it is to be noticed that there are even much more scholars who simply name as paradigm any change in a real (objective as well as subjective) phenomenology or, quite often, in the institutional framework (Kawai; Prasad, 2013). Thereby, the psychological peculiarities of human being led ones to qualify the BMH as a new paradigm related to EMH (although this model did not propose, yet, a closed theory in the matter). Many other models in the financial market, some of them being simple techniques or, at most, methods of approaching, are endowed with the high title of the paradigm.[272] In the same way, the regulatory framework of financial market (or transactions) is negligently called a new paradigm in the financial field. We agree, of course, with the idea that the normative framework drives and/or biases, perhaps in an important degree, the financial behaviour, by either constraints or incentives, but such conditionality is far from the genuine concept of paradigm. In fact, this concept is subject to the same demonetization process as the most fundamental concepts in economic or financial theory (*Nota bene*: today, for example, the concept of sustainability is applied to any imaginable economic phenomenon).

Paradigmatically assessing EMH

From the beginning, it must be mentioned that EMH is presumed to be a praxiological type of paradigm (if it is so).[273] Generally, any economic theory or model is of praxiological nature,[274] because it implies the human being behaviour, that is, decision and action,[275] which engage both the subject and the object. In this context, we shall analyse EMH later, based on our proposal of the three criteria.

Institutive condition

As provided in section "Preliminaries", EMH is edified on the neoclassical economic theory and verifies exactly the suppositions of this theory, so it is a

praxiological paradigm (i.e., of VNFL type), which means it accomplishes the institutive condition, as follows:

- ***V*** (value): *hyper-rationality* (*HR*) of (all) economic agents. By hyper-rationality is understood a rationality which is presumed (a) complete, (b) infallible, and (c) generalized. In Fama's terminology, the economic agents are, all, sophisticated, which means, *inter alia*, that there is no noise on the financial market; the value addresses the individual's credence;[276]
- ***N*** (nucleus): *selfishness* (*E*) of (all and every) economic agent. By selfishness is understood a behaviour that is subject of the own interest of the economic individual (either as biological or organizational one). The competitive or cooperative behaviour (including short episodes of apparent altruism) is, in last instance, subject to selfishness. Regardless of the degree of financial market regulation (i.e., regardless of the relationship between invisible and visible hands in market functioning), the background of any behaviour on the financial market is designed to serve the own (economic) interest of agents;
- ***F*** (function): *optimization* (*O*) of (substantive) utility. As based on neoclassical economic theory (i.e., on *homo œconomicus* model), EMH maximizes the expected utility, as substantive cardinally measured utility. This implies optimization, that is, extremization of function-target subject to a set of measurable constraints. To be mentioned that this is (referentially) equivalent as to speak about expected utility maximizing or about decision's opportunity cost minimizing;
- ***L*** (logic): *methodological individualism* (*MI*). EMH infers macroeconomy from microeconomy, or the same, macrostructure from microstructure. Of course, this is a logical consequence of the theoretical bases of EMH, and EMH must be consistent with them. Problem is, here, that such a logic allows rather a 'one way' causally oriented. The financial market (the macrostructure) is causally generated by the behaviour of individuals, but the individuals' preferences are not considered subject to the macrostructure – in fact, the preferences are viewed as invariant.

Based on the previous descriptions, we can concede that EMH verifies the institutive condition of a praxiological paradigm. However, a question arises now: where is the concept of market efficien , which is the heart of the paradigm in case? Basically, the market efficienc outcome must be contained in the value of paradigm, that is, in the hyper-rationality. Indeed, the final consequence of the hyper-rationality is exactly the exhausting of all opportunities which provide gains over the market average (or, more extensively, a gain as positive difference between returns and costs involved by information searching and risk assuming/covering). Therefore, it is not needed to introduce a new structural component in the paradigm abstract definition, aimed at to describe the market efficien , because such a component would be redundant related to the value (V) of EMH.[277] Verification of the two 'C' of the institutive condition is easy to be performed by the interested reader himself or herself.

Conservative condition

As Kuhn showed, a paradigm must keep itself for a (long) while, in order to exhaust the solutions to the puzzle questions[278] put before it. Unlike Popper, Kuhn does not accept the concept of *experimentum crucis*, so, if an empirical test (or a natural experiment) shows that the market has been beaten, such a result (after, of course, verifying the accuracy of the experiment concerned) is considered as an anomaly face to the normal science, and consequently, it is ignored. Thereby, the concept of anomaly plays the role of a conservative condition/device in EMH paradigm because the anomaly is ignored as long as the disciplinary matrix[279] inside the paradigm is verified. The anomaly label will be pasted on any result that exhibits (or seems to do so) a contradiction with the exemplar solution. Principled, an anomaly does not create problems inside the paradigm until a critical mass of the researchers/practitioners will consider the situation to be too serious to be tolerated (see later the discussion on the regulative condition). So, the conservative condition of EMH is an inertial principle (both of robustness and of resilience nature) which maintains the paradigm concerned in work against the perturbations. Kuhn considers that such perturbations come from inside the paradigm, not from outside of it. However, it was shown that the internal perturbations (namely, anomalies) are 'seen' only in the light of an alternative paradigm which is ripening around the old one but outside of it.

Regarding the conservative condition, a fundamental issue is the (factual) testability of the paradigm in case. Indeed, to establish an anomaly, it is needed to be accurately identified. Is EMH empirically testable? In our opinion, this is a question *per se*, so deserving to be separately examined, firstl , because it is fundamental for the paradigmatic statute of EMH itself. To be mentioned that some scholars even think that EMH is not testable or, equivalently, it is not clear what exactly should be tested in the case of EMH (Titan, 2015).[280] In our opinion, if (factually) non-testability of EMH would be proven without any doubt, then its claim for a paradigmatical statute should be rejected – it could still remain a metaphysic paradigm, without any interest for both science and social practice (*Nota bene*: authors have planned that their next intervention will focus exactly on the testability of both EMH and AMH).

Regulative condition

Regulative condition is a mechanism aimed at to solve the situation in which the conservative condition fails. Like in the cognitive case (i.e., Kuhn-ian paradigm), the praxiological paradigm called EMH has such a regulative mechanism, based on the anomalies established by empirical tests of EMH. As mentioned earlier, the new paradigm ripens together with anomalies accumulated inside the old paradigm. In EMH case, in our opinion, there are three incipient new (potential) paradigms that are now still growing around it: (a) BMH,[281] (b) AMH, and (c) Evolutionary/Institutional Economics. The

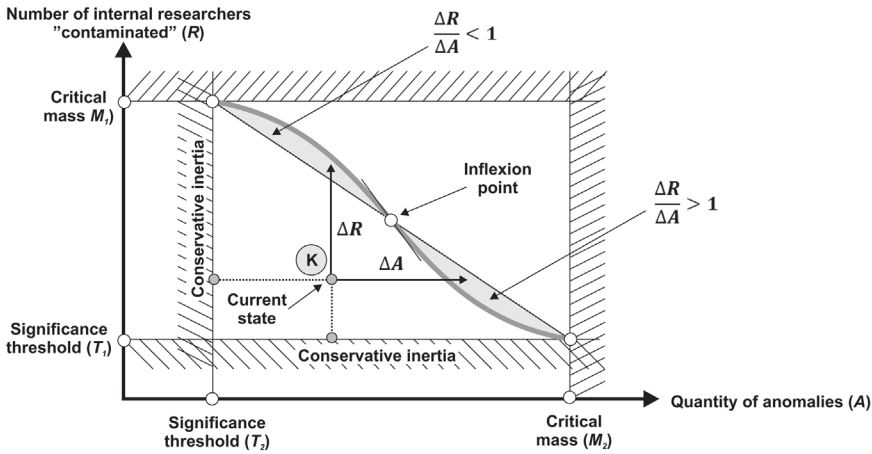

Figure 2.20 Indifference curve in triggering a new paradigm.

Source: Authors.

first two germs are focused on the financial market, while the third regards the larger economic theory (or phenomenology). As said many times earlier, not all germs are destined to become actual paradigms – this chance implies verifying the three criteria proposed here – although any such possibility can illuminate the anomalies growing inside the old paradigm. We hold that such a combination of (three angles of) illuminating has effectively happened with regard to EMH.

The main issue in the regulative condition topic is the combination between the quantity of (recognized and accepted) anomalies, on the one hand, and the number of researchers/practitioners who are working inside the paradigm concerned, on the other hand. In our opinion, we have here something like an indifference curve, probably as Figure 2.20 exhibits.

Firstly, the presumptive indiffer nce curve seems to 'require' a mirror image of a logistic curve. This means that, as the quantity of anomalies grows from small values to greater ones, the marginal rate of substitution of a unit of A with R is smaller than 1 until the inflexion point of indifference curve. After the inflexion point to right, that marginal rate of substitution becomes larger than 1. The number of contaminated researchers/practitioners (with the coming new paradigm) is more important at small quantity of accumulated anomalies than at a large quantity of them, and vice versa.

Secondly, we must consider, for both A and R, a critical mass which signifies the point in which the paradigm concerned can move to a new one without the other part be activated, that is, a critical mass of A (M_2) can lead to a new paradigm without the amount of R to count anyway, and vice versa, a critical mass of R (M_1)

can lead to a new paradigm without the amount of A to count anyway. Of course, both the described situations are only theoretical and at limit, since between A kinematics and R kinematics, there is a causal (or, at least, a conditional) relationship so that an increase of A will attract more Rs, and an increase of R will identify new As. In fact, what is working inside a paradigm is an integrated critical mass of generic anomalies (i.e., which regards both R and A), namely:

$$M = \alpha \cdot R + \beta \cdot A, \text{ where } \alpha, \beta \in \mathbb{R}, \text{ and } \alpha + \beta = 1^{282}$$

As shown in Figure 2.21, such an integrated critical mass is working under the indifference curve constraints.

Thirdly, we must also consider two significance thresholds, T_1 for R, and T_2 for A, respectively. Under significance threshold, no amount of either R or A has the power to move the state towards a new paradigm. Of course, the significance thresholds are conditioned not only quantitatively but also (perhaps, much more) qualitatively – for example, an *anomalia crucis*, or, similarly, a crucial scholar/practitioner, that is, a notorious scholar/practitioner in the field.

Fourthly, in our opinion, with particularization to EMH, both the quantity of anomalies and the amount of 'contaminated' researchers/practitioners inside EMH are under the indifference curve – approximatively at point K in Figure 2.20, although the anomalies 'discovered' are more many than the 'contaminated' researchers/practitioners. So, the marginal rate of substitution of a unit of contaminated researchers/practitioners with anomalies keeps still greater than 1. Our 'prophecy' is that the point K will go rather up than to right, for two reasons: (a) probably the main anomalies have already been identified; b) there is a strong pressure from behaviourism, on the one hand, and from the evolutionary economics, on the other hand, which will increasingly capture the researchers/

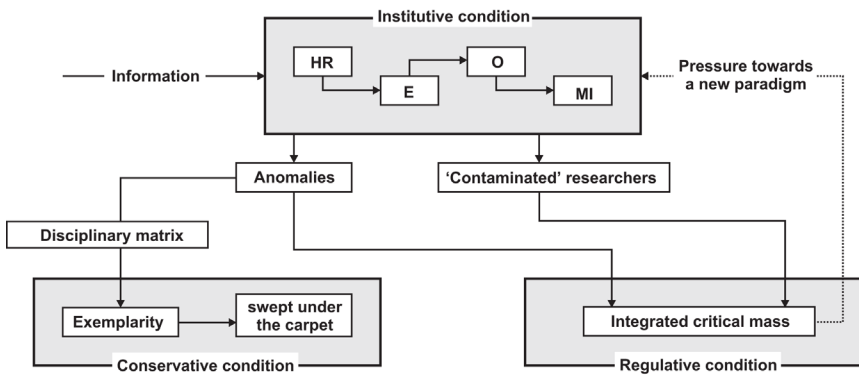

Figure 2.21 General functioning of EMH paradigm.

Source: Authors.

practitioners inside EMH towards new models (potentially paradigms) of fina - cial markets, including AMH.

In the issue, based on our proposal of the matrix of assessing a model *qua* paradigm, EMH can be fully considered as being a paradigm (*Nota bene*: to be noticed that, at least regarding the criteria of conservative condition and the regulative condition, EMH is a paradigm also based on the general requirements of Kuhn's model).

The general functioning of EMH paradigm, according to our matrix of assessing, can be synoptically represented as in Figure 2.21.

Paradigmatically assessing AMH

If, generally, EMH is considered (as self-understood) to be a paradigm of fina - cial market functioning, AMH is just a candidate for such a qualification. Consequently, we shall apply the matrix of assessing to AMH *qua* paradigm in order to establish if this approach verifies (or not) the three criteria of a paradigm.

Institutive condition

Regarding the institutive condition of AMH, we consider the following:

- ***V*** (value): *heuristics* (*H*). In AMH account, the individuals decide and perform actions on financial market based on the trial-and-error mechanism. More exactly, individuals embed their emotions and past experiences in a minimal rationality – formally they use the $RE^{(1)}E^{(2)}$ device which has been mentioned earlier. In a way, AMH approach 'solves' the EMH anomalies which addresses the existence of irrational[283] agents (who induce noise that is exploited by the rational agents). As a result, we think AMH holds this structural component of a presumptive paradigm, namely, *V*. At this point we meet a similar problem as in EMH case: how must be the market on which players are heuristic and not hyper-rational individuals? If in the EMH case, the conclusion was the *informational* efficienc of the market, we think that, in the AMH case, such a conclusion is the *behavioural* effici cy[284] of the market. In other words, the financial market will fully integrate the accessible behaviours (*Nota bene*: similarly with the available information in Fama's formulation. To be mentioned that Lo does not get such a conclusion regarding AMH). As in EMH case, where available information influences the price if only it is used in effectively performing a transaction (otherwise, the information is not integrated into the price at all), in AMH case, if a trading strategy is not used, the financial market cannot change its permissive framework regarding the trading strategies, so it cannot select (by either corroborating or refuting) that strategy. Since the financial market is nothing else than the set of trading strategies actually operated, its adaptation (in Lo's understanding) is exactly the new nomenclature of trading strategies which have succeeded.

The behavioural efficienc of the market means that no used strategy in the past can be used in beating the market, because all of them have already been integrated in the 'accepted nomenclature' of trading strategies, for example, by being taken over by other *attentive and reflective*[285] (not absolutely rational, of course) agents (we shall return later to this topic). The heuristic behaviour on the financial market is a combination of three bearers (vehicles) of patterns: *semetic* (or normative/intellectual) framework (for the term R), *memetic* framework (for the term $E^{(1)}$), and *genetic* framework (for the term $E^{(2)}$);

- ***N*** (nucleus): *adjusted selfishness* (*AS*). Individuals who function under AMH are still selfish (egoistic). This means that they follow their own interest, but this time, we are talking about a kind of an adjusted selfishness, by which we understand the following sufficienc predicates: (i) not only the individual is considered but also the group to which that individual belongs; (ii) this often results in a kind of altruism assigned to the group or, equivalently, in a group-based selfishness; (iii) the balance between individual-based selfis - ness and the group-based selfishness seems to be an empirical issue, not a theoretical one, unlike the EMH's selfishness which is rather theoretical. So, it seems that AMH holds the structural component of a presumptive paradigm, namely, *N*;
- ***F*** (function): *surviving* (*S*). Like in EMH case, where *F* is inferred from *V*, within AMH surviving is inferable from heuristics. Individuals cannot and wish not to extremize their (substantive) utility from their decisions and actions but rather to get a sufficien utility (*Nota bene*: see again, here, Herbert Simon's concept of satisficing, as mentioned in note 38 in Chapter 1). So, if EMH presupposes the first best solution, AMH requires/accepts a second-best one. To be mentioned, however, that individuals under AMH do not deliberately abstain from getting the first best; they simply are content with the best *accessible* outcome, in the context in which, first of all, their (economic) life is preserved. Consequently, we must consider that the chosen of the second-best solution is placed at the top of all accessible second-best solutions (so it is a kind of a maximin solution).[286] Consequently, AMH holds the *F* structural component of a presumptive paradigm;
- ***L*** (logic): *methodological holism* (*MH*). Holism is a (philosophical) vision on the world functioning stipulating that the system dominates its parts (rather than inversely), or, in other words, the parts can be understood through the embedding system (rather than inversely). Such a logic implies that macrostructure is not simply a mechanical aggregation (logical summation) of microstructures but, rather, microstructure is driven by macrostructure. Applied to AMH, this means individuals decide and act inside a macro framework (e.g., normative one) so, at least partially, the micro-behaviour on the financial market can be understood (maybe, not completely, however) starting from the lines of force of that framework. The adaptive markets in AMH play a co-adaptation and a co-evolution game with the trading strategies actually implemented on the financial

markets, in the context in which those trading strategies are designed (and assessed) based on the macrostructure of the economic system in case. We think, so, AMH also holds the structural component of *L* of a presumptive paradigm.

We shall conclude that, from the institutive condition perspective, AMH can be considered as being a (praxiological) paradigm on the financial market.

Conservative condition

It is now required to examine if AMH holds a conservative condition or mechanism, aimed at to keep this hypothesis alive against anomalies. More exactly, we must see whether the anomalies are possible under AMH and, if so, whether these anomalies can be (at least in a given quantum, and for a given while) ignored without putting AMH under pressure or under uncertainty, as well as, of course, whether can exist an 'escape angle' from AMH to an alternative paradigm.

Firstly, we shall discuss the concept of anomaly inside AMH. Based on the general description of AMH (see section "The concepts of modelling and model"), an anomaly means a failure of the financial market to corroborate a trading strategy which performs gains above the market average or, symmetrically, to refute a trading strategy which fails to accomplish such a performance. A failure of a trading strategy should be considered, of course, a result of a wrong choice of it. Such a wrong choice could occur from one (or more) causes as (i) a violation of the normative framework (i.e., violation of the methodological holism); (ii) a violation of disciplinary matrix; and (iii) a violation of the puzzle integrability by the presumed paradigm of the research/practice issues or of the obtained results.

Secondly, we come back to the concept of behavioural efficie y of the fina - cial market, earlier introduced, in order to extra clarify it from the perspective of the conservative condition in AMH:

- attentive and reflective economic agents notice the succeeded or failed trading strategies (*Nota bene*: this phenomenon is not of information availability nature, as in EMH, although, in a sense, they are like the event-based information);
- consequently, the succeeded trading strategies are imitated (memetic behaviour) by those attentive and reflective agents, and, so, we can say that the financial market selects, by corroboration, such strategies;
- by increasing the weight of the imitated trading strategies, in fact, the fina - cial market suffers a process of adaptation,[287] as Lo claims. There is a true phenomenon of selection of populational type;[288]
- so, the financial market behavioural efficienc means that no past trading strategies can get gains over the market average because such kind of strategies are already in force on the current market, exactly by memetism.

Thirdly, so, the question is here: is there, in AMH functioning, something like a disciplinary matrix?[289] We shall examine further this crucial issue:

- a disciplinary/practitionary matrix should be an internal device of selection regarding scientific issues examined, methodology (or research practice) applied, and acceptable results obtained;
- a disciplinary/practitionary matrix in AMH should mean that any succeeded trading strategy has immediately generalized among economic agents, and correlatively, any failing trading strategy has already disappeared from the market;
- however, similarly with the irrational (non-sophisticated, in Fama's terminology) agents in EMH paradigm, in AMH case could exist non-attentive and/or non-reflective agents in watching the trading strategies which are used on the market (we would name such agents as desynchronized agents, with the abbreviation DSAs). The DSAs either will continue trading strategies proved as wrong or do not (yet) adopt trading strategies proved as successful;
- in our opinion, AMH could exhibit these kinds of anomalies (which have many connections with the concepts of inertia/momentum in EMH). But, this time, the cause of anomalies is not located in irrationality, because AMH is 'working' with the trinomial $RE^{(1)}E^{(2)}$, where the rationality is only one of the potential causes. As pointed out earlier, the main causes are, in a lexicographic order of relevance, $E^{(2)}$ (i.e., preference, linked to emotion), $E^{(1)}$ (i.e., memory and representations of the past, linked to experience), and R.

Regarding the conservative condition of AMH, we can conclude as follows:

1 it can be detected as an internal device to provide the AMH conservation, as a pattern of behaviour on the financial market, namel , the DSAs;
2 the persistence of DSAs on the financial market is depending also on the inertia feature of the financial market, which introduces lags into the selection (and adaptation) process of the financial market;
3 like the irrationals in EMH, the DSAs in AMH can persist and replicate themselves, in a separate sui generis process of selection/evolution;
4 like in EMH, when the rationals exploit the (informational) noise introduced by irrationals, in AMH, the SAs (i.e., the synchronized agents) exploit the (behavioural) noise introduced by DSAs on the financial market.

Therefore, from the conservative condition perspective, AMH can be considered as being a (praxiological) paradigm on/of the financial market.

Regulative condition

What now we have before us is to examine if, in AMH, there is a device which, based on specific internal anomalies (as discussed earlier), can lead to a new pattern of behaviour so that AMH is replaced by that new pattern. As Kuhn's

provisions and the previous discussion about EMH suggest, we have, in fact, to put into evidence a logical consequence of the dynamics of DSAs on the financial markets. After that, we must identify whether this consequence has the (irreversible) potential to claim a new pattern (which, in its turn, should be examined under our matrix of assessment of a pattern *qua* paradigm), likewise in the case of EMH.

THE FINALITY OF ANOMALIES IN AMH

The anomalies in AMH consist, as it has been explained earlier, in the incapacity of financial market to operate the selection among trading strategies – by corroborating and, so, extending the use of successful strategies, and, symmetrically, by refuting and, so, narrowing (and, ultimately, make disappearing) the use of the failing strategies. Is such an incapacity real? We shall further provide some pro arguments:

- the behavioural efficienc of the market has, *mutatis mutandis*, the same referential as in EMH: the maximum entropy of the market, which means the impossibility to find niches capable to provide returns above the average of the market (or equivalently, gains above the cost involved by information searching and extra risks assuming). (*Nota bene*: to be noticed that such meaning of efficienc is viewed from the market side, not from the agent one – from the agent side such an efficient market is inefficient
- suppose the financial market selects the successful trading strategies (further as GTSs – good trading strategies), by the memetic mechanism operated by SAs. This way, the GTSs become dominant, and, in the same degree, the market becomes behaviourally more efficient (*Nota bene*: here a conclusion is important: unlike in EMH case, in AMH, the behavioural efficienc has degrees of actualization.);
- the DSAs will continue to use failing trading strategies (further as WTSs – wrong trading strategies), allowing SAs to gain above the average of the market. The winner SAs will extend using WTSs until they will be selected (i.e., corroborated) by the financial market, and this oscillation can go on, principled, indefinitely;
- this way, the GTSs and WTSs will reciprocally replace one another, so the anomalies can never accumulate over a given threshold (as in EMH case). We can find here an analogy with the competition between Lakatos's research programs (which replace Kuhn's paradigm);
- such a necessary statement (to some extent, surprising) leads us to the conclusion that AMH cannot be considered as a paradigm on/of the financial market, because it fails in verifying the third criterion of our matrix of assessment of a behavioural pattern *qua* (praxiological) paradigm. Lacking the regulative condition (or device), AMH is not capable to pass to another pattern of behaviour which explains its current anomalies more and better, as AMH claims it had, in turn, made as regard both to EMH and BMH;

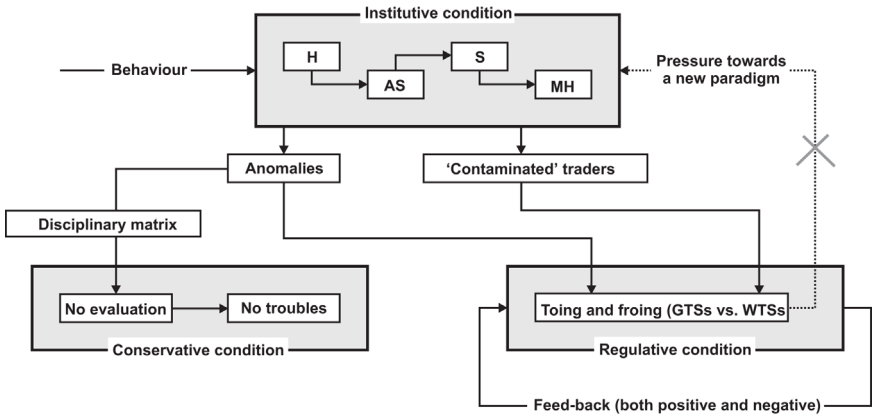

Figure 2.22 General functioning of AMH paradigm.

Source: Authors.

- we want to highlight for the reader the fact that GSTs and WTSs work as mutual automatic stabilizers, driving the AMH 'system' to a kinematics of toing and froing process.

QUO VADIS AMH?

In other words, showing that AMH lacks the regulative condition (or device or principle), we have shown, implicitly, that AMH lacks a concept of equilibrium (to be observed that EMH is 'endowed' with such a concept, namely, the complete, even asymptotically, disappearing of the opportunities to beat the market). The (logically necessary) reciprocal exchange of places between GTSs and WTSs blocks any propensity to an equilibrium, even if such an equilibrium would never be actually reached.

In our opinion, AMH is a temerarious project aimed at to provide a realistic and (much more) simple model of financial behaviour, based on the real human being, with its own biological heritage and cultural aspirations. We strongly believe that on this project, it deserves to meditate further and courageously. Some directions in which it can be fruitful to develop AMH are listed later.

In mirror with EMH (see Figure 2.21), in Figure 2.22 is shown a synoptical view of AMH functioning, based on the outcomes found out earlier.

Results

AMH works based on the trinomial: $RE^{(1)}E^{(2)}$ (i.e., rationality – experience – emotion), while EMH holds only the uninomial R (as regards BMH, it seems to hold the binomial $E^{(1)}E^{(2)}$). In order to analyse a behavioural pattern *qua*

paradigm, we propose an ICR (institutive – conservative – regulative) logical device, where the institutive condition/principle contains four structural components lexicographically ordered: value – nucleus – function – logic. The institutive condition has been particularized to the two behavioural patterns examined as follows: for EMH – the value is hyper-rationality, the nucleus is selfishness, the function is optimizing, and the logic is methodological individualism, while for AMH – the value is heuristics, the nucleus is extended selfishness, the function is surviving, and the logic is methodological holism. By applying this device to EMH and AMH, respectively, we have obtained that EMH is a (praxiological) paradigm, but AMH is not such a paradigm, because it lacks the regulative condition/principle – to be mentioned that to get a lack of regulative, it was needed to replace, in AMH, the informational efficien , as in EMH, with the behavioural efficien .

In getting such a result, we have introduced the concepts of GTS and WTS, respectively, and have shown that GTS and WTS transit from one to another, in an endless process based on the institutive condition of AMH, in fact a self-maintained oscillation (i.e., a toing and froing movement, driven by the so-called – in the evolutionary terminology – populational selection and adaptation). This result is, somewhat, a necessary one once the informational effic ncy (in EMH) is replaced by the behavioural efficienc (in AMH). We have proposed an analogue for the irrationals in EMH, namely, the DSAs who play, regarding the trading strategy, the role that irrationals play regarding the information. In other words, it can be said that AMH is a stationary paradigm.

The concept of stationary paradigm can be, in our opinion, an openness to extend AMH towards an autopoietic concept of paradigm (in the praxiological sense, of course). In fact, perhaps, only the cognitive paradigms can remain Kuhn-ian, while the praxiological ones have to become non-Kuhn-ian: a non-Kuhn-ian paradigm is one that lacks the regulative principle (as regards the comprehensive type of paradigm, it has not been examined in the volume). This result is, in our opinion, of significant relevance because it could lead the scholars interested in this matter to develop further the AMH pattern in order to bring it to the statute of a real (perhaps, non-Kuhn-ian) paradigm on/of the financial market.

Conclusions

We have proposed a matrix of evaluation of any behavioural pattern *qua* paradigm in the financial market (in fact, in an economic field) based on three criteria: institutive condition, conservative condition, and regulative condition. These criteria are, partially, the result of a logical abstraction based on the sociological (and historical as well) approach of Thomas Kuhn in his proposal of the (cognitive) paradigm and are aimed at to be applied to the general (master) paradigm which we have called praxiological paradigm – as EMH is and BMH or and AMH could be. Regarding the institutive condition, we have departed from Kuhn and have proposed four structural components of any (possible) paradigm: value, nucleus, function, and logic.

An especially important issue of the concept of paradigm (on which Kuhn extensively and quite controversially debated) is the incommensurability between the new paradigm and the old one which the former replaces. Regarding the pair EMH-AMH, of course, this constitutes a promising reason for a productive discussion in this context. But, since, in our opinion (and as proved in the paper), AMH is not properly a paradigm on/of the financial market (because it lacks the regulative principle), such a discussion is neither necessary nor possible anymore. Maybe, after one finds (or proves) that such a regulative principle could or should be accepted, the discussion could be resumed.

Many (or, more exactly, most of the) studies dedicated to financial paradigms start from Kuhn and try to find analogies in their specific targets, without noticing that, this way, a cognitive model of paradigm is applied to a praxiological pattern (*Nota bene*: it is an analogous phenomenon with that of the cheerful econometricians who apply stochastic models to deterministic processes).

The AMH's claim that it integrates EMH and BMH is, in our opinion, Lo's risky positioning, because, as we have shown earlier, except (not in entirety) the function, all the other structural components of AMH are placed in diametrical opposition with the corresponding components in EMH. Consequently, Lo's claim that EMH is a particular (i.e., at limit) case of AMH seems to be, equally, unsupportable.

Although we agree with economic (and financial, especially) theory salvation from the physicalist imperialism (of which Samuelson is the main 'guilty'), we agree, equally, with the idea that the logical reflection is, probably, the best tool to clarify, ordering, and construct paradigms in the economic (more general, social) field. The crucial argument we can provide for that preference consists in that the logic approach avoids induction, which is too propensive towards the false. History, sociology, anthropology, (both cognitive and behavioural) psychology, and other of the same type are strong (and inestimable) ways to test factually these constructions, but the constructions themselves should be deductively (more exactly, abductively) edified. It is what we have tried to provide in this volume.

Suggestions for future research topics

Based on the presentation in this chapter, we consider that scientific subjects in two research lines are potential for development:

I. In the field of financial market

- the mix between cumulative selection and punctuated equilibrium in the case of adaptive preference on the financial market;
- a cobweb model on the mutual adjustment between the specialization curve and the niche curve on the financial market;
- the concept of quasi-species on the financial market and its methodological and instrumental implications;

- modelling the fitness of the trading strategy on the financial market
- the concept of quasi-financial market (based on the concept of quasi-species);

II. In the field of mathematics applied to the financial market

- determining the 'colour' of the punctuated balance on the financial market;[290]
- determining the colour of the predominant noise on the financial market (which seems to be, from a conceptual point of view, pink, not white);
- differential formalization of the hypercycle in the phenomenology of adaptive preference (or, equivalent, of the adaptive market);
- aspects of temporal topology in the kinematics of the trading strategy on the financial market [291]
- formalizing the propensity probability on the financial market.

Notes

1 For example, the famous theory of generalized relativity that it is reducible to the following hypothesis: gravitational motion is not discernible from accelerated motion.
2 Ironically, the market is efficien (in the sense of EMH theory) when it is completely inefficien for the economic agent (i.e., when it cannot earn, in any way, above the market average). So, efficienc is seen here from a market perspective, not from the perspective of the individual, trading on the financial market. Our research option is to look from the opposite side, that is, from the adaptive preference, which is an attribute of the agent.
3 The idea of representation is fundamental in modelling. In fact, the concept of representation in the model is analogous to the concept of representation in consciousness, that is, it is (semiotically) a sign (or, rather, a macro-sign), which means that the representation stands (or must stand) instead of (or for) the reality in question. To stand in the way of reality, the model, as a result of modelling, must be based on the *ex-ante* knowledge (not to confuse *ex ante* knowledge with *a priori* knowledge!) of the reality that needs to be modelled.
4 This impoverishment, however, has, in fact, the significance of an essentialization: cognitive loss refers to the loss of only the non-essential aspects (predicates) of modelled reality.
5 The logical 'order' here is as follows: (1) the elaboration (in fact, the discretionary or even arbitrary choice) of axioms; (2) based on axioms, the elaboration of the theory/hypothesis; (3) based on the theory/hypothesis, the elaboration of the consequences/lemmas; (4) based on the consequences, the elaboration of predictions (predictive statements); (5) based on the predictive statements, the execution of empirical/factual experiments; (6) based on the experiments, the formulation of descriptions (descriptive statements); (7) based on the semantic comparison of the predictive and descriptive statements regarding the same factual (empirical object), the corroboration decision versus the refutation decision of the hypothesis/theory involved in testing. We remind that only the refutation decision is decisive, while the corroboration decision is indifferent in relation to the 'fate' of the theory/hypothesis involved (the corroboration neither strengthens the respective theory/hypothesis nor increases its probability of being true; behaviourism seems to indicate an increase in this probability. We will examine this aspect further in the study).
6 In general, there are two major testability classes of the theories/hypotheses: (a) *logical testing* – the internal correctness of the formulation of the theory/hypothesis, including

grammatical correctness; and (b) *empirical testing* – the semantic correspondence between the content of a prediction regarding a given factual and the content of a description regarding the same factual (this is the content of the famous Popperian falsifiability). In this context, it is considered that only the empirical testability (*Nota bene*: not the effective testing but the testability, i.e., a certain possibility of testing) ensures the scientificity of a theory/hypothesis. For example, a metaphysical or literary theory can successfully pass the logical test, but that does not turn them into sciences, because obviously they are not empirically (factual) testable.

7 A typical example of this pass, to refer strictly to the financial market, is the functioning model of the *hedger-speculator* relationship (*the hedger* is an agent who trades assets or derivative prices, and *the speculator* is usually a bank): on the basis of the hypothesis of the absence of arbitrage, in the case of forward contracts, mathematical models related to this hypothesis are elaborated (Elliott & Kopp, 2005).

8 Reality has three components: (1) *objective reality* – which has an ontological status independent of the knowing/observing subject (Popper's first world); (2) *subjective reality* – which has an ontological status dependent on the knowing/observing subject (Popper's second world); and (3) *objectified reality* – which has an ontological status as objectification of inter-subjectivity (Popper's third world). In the economic (broader, social) field, the third world is predominant – for example, all theories/hypotheses and models are part of Popper's third world, that is, reality as an objectification of inter-subjectivity.

9 The principle of *intelligibility* refers to any knowledge, not just scientific knowledge – for example, religions are intelligible models of the world (like the myths that often underlie religions); likewise, political or moral ideologies.

10 As Frank Knight has known, uncertainty is not the equivalent of risk; conceptually, a risky environment is a species of uncertainty environment – while the risky environment is modellable by probability distributions associated with the events in the probability field in question, the uncertainty environment cannot be modelled in any way.

11 We recall that, for example, the reaction of behaviourism (and, subsequently, the reaction of AMH) to neoclassical economic theory (respectively to EMH) starts precisely from considering the irrationality of individuals' behaviour on the economic market (and on the financial market), by putting in evidence of the so-called anomalies that accompany the EMH model. Behaviourism applied in the financial field (and which, thus, is also called *behavioural finance*) has two major areas of interest: (a) cognitive psychology and (b) the limits of arbitrage (in the case where informational arbitrage is possible, i.e., in the case of inefficien markets within the meaning of Fama).

12 However, probably more than half of the 'scientific' articles, including in the field of financial market functioning, are written in the margins of the *homo œconomicus* model.

13 The conceptual distinction between rational, irrational, and a-rational is examined (including formally) in Chapter 1.

14 This 'blindness' is one of the fundamental features of Kuhn's concept of paradigm – the ignoring of results that are not 'expected' in the paradigm margin (these results are called *anomalies* and, until a critical mass of them is reached, are ignored by so-called normal science). Recall that, for example, even in empirical testing of the EMH, we talk about anomalies (of timing, of size, etc.).

15 A syllogism is a type of formal judgement with three terms: (a) a major premise or covering law, which expresses a universal (or at least general) law; (b) a minor premise, which expresses a particular case; and (c) a conclusion, which draws the valid consequence by applying the major premise to the minor premise.

16 If the major premise is M, the minor premise is m, and the conclusion is C, *modus ponens* has the following form:

$$M \rightarrow m$$
$$M$$
$$C = m$$

17 If the major premise is M, the minor premise is m, and the conclusion is C, *modus tollens* has the following form:

$$M \rightarrow m$$
$$\bar{m}$$
$$C = \bar{M}$$

18 A brief assessment of the analogy from the perspective of modelling in general (and modelling in economics in particular) is presented in Annex 1.

19 We will consider the labour force, object of the transactions on the labour market, as belonging to the exchange of services, it's true, the most special services in the economic process.

20 The 'standard' way in which the market is seen – as the whole of the exchange of goods and services – must be complemented by two other objects of exchange: (a) information (see, e.g., agent theory or even EMH, which refers exclusively to the informational aspect of the functioning of the market, both non-financial and financial): there is a process of searching for information (which also led, besides, to the concept of transaction cost), and most theories and models of the financial market are *informational-based* constructed (we will see, in the body of the study, that, it can be considered a more appropriate way of modelling the market, namely, behavioural-based modelling); and (b) symbols: along with the substantive (or economic) utility, there is also the symbolic utility that acquires more and more relevance as the economy becomes more digitized and closer to the real goals of man (different from current consumerism).

21 The objective of the present study does not extend to the development of an internal typology of the financial market, although it would be, from other perspectives, relevant. Therefore, in the concept of financial market, we will include, in a broad sense, all transactions that are derived from transactions with goods and services (which remain the real support of traded financial objects), and in a narrow sense, we will include in the concept of financial market only transactions from the capital market.

22 There are three categories of economic flows in the economy: (a) *real flows* – autonomous non-monetary flows, that is, subject exclusively to the demand-supply ratio, and which are intended for direct consumption (usually current); (b) *financial flows* – related cash flows, in the sense that they are counterparties to the real flows (e.g., price); (c) *nominal flows* – non-autonomous cash flows (but not necessarily related) both in relation to the real flows (which, however, constitute their last resort) and in relation to the financial flows, with which they are inter-conditioned (e.g., shares, which have as support the capital shares – real flow – and which are inter-conditioned with price – financial flow)

23 The term *derived* has a different denotation from another term, *derivative*. The derived is a contract on financial market transactions that establishes its value (price) on the basis of the performance of the derivative (so to speak) – examples of derivatives: forward contracts, future contracts, option contracts, and swap contracts, which depend on performance (yield) assets, indexes, and interest rates.

24 As Keynes himself (as well as many other thinkers on the economic process) has shown, the main (if not the only) ultimate cause of economic crises is the discrepancy between real economic flow (i.e., support) and financial flow (or, with a more appropriate term, *nominal flow*). From time to time, this discrepancy settles down, and then the economic crisis occurs. From this point of view, there is never an economic

crisis – probably here Marx was wrong about his crises of over-production – but only a financial crisis (more precisely, nominal) which, of course, also affects the real economy, becoming an economic crisis, but only as a spillover (it did not happen, apparently, with the crisis triggered in August 2007 in the United States).

25 In specialized terminology, a financial instrument is called a *security* (plural – *securities*).

26 A contrarian game (or behaviour) is a game that relies on the opposite of the observable (i.e., public) dynamics of the market. For example, when everyone expects the price to follow the 'return to average' trend – see here also Kahneman's contributions on economic behaviour and who argues about a propensity of any dynamic to the average of that dynamic. *Nota bene*: here it is appropriate to use the concept of propensity probability, proposed by Karl Popper – an agent will apply a contrarian strategy, that is, a strategy that relies on 'diverting from average' of the price (in other words, a contrarian strategy can be defined as a *counter-momentum* strategy).

27 We do not confuse causality with the principle of causality: while the principle of causality refers to the way in which the reality (objective, subjective, or objectified) works (emerges, changes, evolves), the causality refers to the actual manifestation of a cause or a set of causes (multiple causes). Many times, we do not know the cause, but we cannot doubt the principle of causality. Similarly, indeterminism (i.e., the functioning – in itself or only for our mind of) of reality, statistically/stochastically, does not mean that it, reality, evades the principle of causality (*Nota bene*: remember that the stochastic only targets statistics, while random can also refer to dynamic).

28 The model provides both factual testing (the only testing, at least in the view of the philosophy of science promoted by Karl Popper, which gives scientificity to a theory or research result) and logical testing – checking consistency, coherence, and completeness (the three 'C') for the considered theory/hypothesis.

29 As we will see, this 'co-evolution' of the associated theory and model was repeated in the case of the EMH.

30 If we were excessively pedants (but rigorous), the financial market should be called the nominal market. But, of course, we do not want to be (too) pedants in the body of this study.

31 Consistency means non-contradictory, exactly in the sense of the principle of non-contradiction in bivalent (Aristotle-ian) logic: $\overline{A \wedge \overline{A}}$.

32 One possible objection, here, is that it would claim that there is another model of economic behaviour, even one that has aroused (like EMH) the interest of the Nobel Committee, namely, the behaviourist model. In our opinion and, moreover, of many analysts in the field, including Lo, behaviourism has not produced (yet) an articulated theory of economic choice, being, for now, only a collection (very interesting and potentially challenging for new syntheses theoretical, as is Lo's attempt with AMH) of (artificial) experiments. There are, of course, fulminating (empirical) results, such as Kahneman's prospect theory or Thaler's niche theory, but they are still waiting for the theoretical framework to integrate them in a coherent, generalizing, and complete way.

33 There are authors who consider that there is another logical model of the functioning of the economy (thus including the financial market), namely, *the rational expectations model* (Lo, 2019). In our opinion, this model is reducible to the EMH, as it is still based on the idea of equilibrium, on the one hand, and is 'immersed' also in the neoclassical economic theory, on the other.

34 Details of the origin and successive contributions of a theoretical nature (note that Fama started the construction of this model from an empirical, not theoretical, perspective) on this concept were mentioned in Chapter 1. We mention here that the term *EMH* was not introduced by Fama, who in 1965 introduced only the concept of efficien market (Fama, 1965), but by Harry Roberts (1967), who also introduced the three forms of informational market efficien , all of which were taken up by Fama in 1970 (Fama, 1970).

35 It seems that, in recent years, this (unproductive) predilection of the Nobel Committee has been more subdued, especially under the 'blows' of behaviourism.
36 In other words, no net gain can be achieved in the market by using information arbitrage (information arbitrage assumes no transaction costs).
37 From an entropic perspective, the efficien market expresses the maximum entropy of the financial market.
38 Obviously, such a conclusion should have been devastating for all the so-called Wall Street *quants* who, however, continued to operate their patterns of price behaviour in the financial market (Lo, 2019).
39 We do not refer here to the three categories of market information efficienc (weak, semi-strong, and strong) which are not relevant in the context of this study.
40 *Over-reaction* and *under-reaction* (to information) behaviours are found in behavioural economics. Some authors consider them anomalies in relation to EMH, but in fact, in our opinion, they are elements of 'friction' that EMH (based on *homo œconomicus*) ignores.
41 *Momentumness* is the opposite of *randomness*. Thus, momentumness strategy is buy, if there is positive auto-correlation (or positive relative strength), and sell, if there is negative auto-correlation (or negative relative strength).
42 This is the fundamental reason why the EMH model is not empirically testable (i.e., in the Popperian sense of science). This is why the plethora of empirical studies (some 'confirming' EMH, while others 'rejecting' this hypothesis) are of no scientific value but have contributed to the Hirsch's rise of tens of thousands of article writers on the subject.
43 More precisely, the study will propose a model not of *informational market efficiency* (as EMH does) but a model of *behavioural market efficiency*, as AMH suggests (rather unsystematically, as we shall show). For this we will make use of some extremely interesting suggestions coming from biology, specifically the *hypercycle* concept.
44 In a technical expression, it does not provide a model for the structure of information available to investors. In financial mathematics, the structure of accessible information is as follows (Elliott & Kopp, 2005):

- either a set of time moments: $\mathbb{T} = \{0,1,\ldots,T\}$; be a probability space: $(\Omega, \mathcal{F}, P)$, which models all possible market states; the only role of P is to identify events that are possible (namely, those for which $P > 0$);
- the structure of the information is given by the (increasing) sequence of subspaces ($\mathcal{F}_t$) from the probability space;
  - $\mathcal{F}_0$: contains only events with probability 0 or 1;
  - therefore: $\mathcal{F}_0 \subset \mathcal{F}_1 \subset \ldots \subset \mathcal{F}_n = \mathcal{F}$;
- such an increasing sequence is called *filtering* $\mathbb{F} = (\mathcal{F}_t)_{t\in\mathbb{T}}$;
  - so $\mathcal{F}_t$ contains the information available to investors at time t;
- investors are considered small investors – they do not change the probability of events by their actions; (*Nota bene*: similarly to atomistic economic agents, who are not price makers, so investors *are not probability makers*)
- partitions on event space (Ω) are also in an increasing sequence: $\mathcal{P}_0 = \Omega \subset \mathcal{P}_1 \subset \ldots \subset \mathcal{P}_n = \mathcal{P}$;
- each investor knows which cell (witch $\mathcal{P}_i$) contains the true state of the market but knows no more than that.

45 In fact, we will soon see, that the AMH does not offer such an integration mechanism either (this time of both information and behaviours 'available' on the market).

46 As we know, the categories of targeted information differ according to the category of informational efficienc (weak, semi-strong, strong), but it seems that this typology of market informational efficienc has no theoretical, methodological, or empirical relevance, although analysts can use the differences between them (in terms of information structure) to identify test criteria.

47 The economists of the time did not understand the subtlety of Samuelson's proposal and settled for the random walk model (it is obvious, however, that the random walk hypothesis does not exhaust the fair game hypothesis required by the martingale; *Nota bene*: previously, Bachelier had also considered the fair game hypothesis, although, technically, he operated with the random walk, which was also considered under the normality condition of the price distribution). Instead, before Bachelier, Cardano used a martingale, as would later Samuelson (Posenato, 2018). The martingale hypothesis (as a stochastic process) can be expressed as follows: in monetary terms, the expected profit at a given point in time, given past total capital, is zero with probability one.

48 Building on Fama's proposal, a number of techniques have been developed that are commonly used in the process of choosing a trading strategy in financial markets: (a) Capital Asset Pricing Model (CAPM) (*Nota bene*: Fama (Fama, 1993) considered firm size to be a better measure of risk than the *beta coefficient* in the CAPM); (b) Markowitz's portfolio; (c) Sharpe ratio (SR); (d) Black-Scholes/Merton Theory and Black Scholes Option Pricing (BSOP); (e) Arbitrage Pricing Theory; (f) Cox-Ingersoll-Ross Theory – of course, all these techniques are tributary to the (non-realistic) *homo œconomicus* model.

49 Of course, this is where another problem arises that should be solved (but impatient people have pounced on the use of the fractal technique without reflecting on it, typical of article writers), namely, the very assumption of the fractal model of the financial market (just as martingale provided the model of a stochastic – i.e., fair game – process of the financial market). In essence, fractal analysis is justified because stochastic time series modelling is relatively coarse (in fact, fractal theory replaces stochastic modelling with chaotic modelling, which seems closer to the reality of the financial market).

50 We follow, here, closely, the synthesis provided in (Posenato, 2018).

51 One of the reasons why EMH cannot be tested empirically (neither in artificial nor in natural experiments) is the assumption of zero transaction costs in the acquisition of past and current information that is embedded in the price: such an assumption is simply impossible to fulfil in experiments.

52 Samuelson pointed out that the fair game theorem (the martingale he introduced) formulated as follows: 'the price change from its fundamentals is zero' is a theorem that cannot be tested empirically, because no experimentally testable or even observable factual predictions can be made. To be mentioned, at this point, that the gravitation of the actual price near its fundamentals is equivalent to its gravitation near its natural level – the natural level of the price is the level at which price equals value. We mention that one of the objectives of the research aims is to develop a scientific result (or a proposal) on the formation of the natural level (price, yield, etc.), which will be addressed in the second volume to be released.

53 In 2015, Titan said it was unclear what should be tested for EMH (Titan, 2015).

54 There are three categories of analyses that can be used to 'test' the EMH: (a) study of events (e.g., an announcement by a non-financial firm); (b) econometric tests on linear models (uni- and multi-factor); and (c) anomalies.

55 From a technical point of view, there are several 'colours' of noise (hence, several categories of irrational agents): white noise, black noise, pink noise, between which there are rigorous mathematical relationships (particularly for the continuous case, using derivatives). We will return to the typology of noise colours.

56 Significant is only the lag between the number of expected roads and the number of roads actually produced; an effecti e number less than the expected number means positive self-correlation and vice versa.
57 The following tests/methods can be used to establish this conclusion: (a) price/earnings ratio; (b) price-to-book ratio/market value ratio (stock price/catalogue price ratio is calculated as the value of assets minus liabilities, divided by the number of outstanding shares). Essentially, the problem of financial market predictability is to establish (modelling) the rapport between price and value (Malkiel, 2003).
58 This is an effect similar to (a) the Monty Hall problem (the three-door problem) and (b) the Bertrand box paradox.
59 The first chapter of the second volume to be released will propose such a structure of information, both conceptually and operationally.
60 Similarity, the frictionless mathematical model in Newtonian physics of sliding on an inclined plane, is not empirically testable, so this model is completed by introducing the friction coefficient before testing it factual .
61 The mathematical model used by Grossman and Stiglitz is based on Robert Lucas's model of noise in rational expectations theory (a model that considers all information flows). Lucas's model shows that prices weighted by marginal utility (in turn based on rational expectations) follow a martingale. Of course, this is subject to the three conditions that rational expectations theory must satisfy: (a) the scarcity of information, (b) the existence of a rationality model, and (c) the assumption that the public prediction does not produce effects (so there is no Oedipus eff t).
62 In order to 'beat' the market, a number of techniques have been developed to choose trading strategies, such as (a) pairs trading, (b) value strategy, (c) momentumness strategies, (d) short-term reversal, and (e) contrarian strategies.
63 This is, as will be seen, a theoretical paradox, that is, of a logical nature.
64 The GS model actually has seven conjectures: (1) the higher the number of informed agents, the more informative the price; (2) the higher the number of informed agents, the higher the expected utility ratio (informed vs. uninformed agents), namely: the lower λ is; 3) the higher the cost of information, the lower λ is; (4) increasing the quality of information leads to higher dependence of the price on θ (θ is an observable that implies a transaction cost); (5) increasing noise leads to a decrease in the informativeness of the price, hence a decrease in the expected utility of uninformed agents (at equilibrium: as noise increases, λ increases); (6) if there is no noise, all information is included in the price (if someone pays for information that is not included in the price, then he becomes an informed agent, so the market is no longer in equilibrium); (7) *ceteris paribus*, markets are thin when $\lambda=0$ or $\lambda=1$. *Nota bene*: *thin markets* – as opposed to tick markets: thin markets – high degree of product differ ntiation; *thick markets* – low degree of product differentiation.
65 Some of the anomalies catalogued are generated by so-called myths that are associated with EMH. See mention of these myths in Chapter 1.
66 See Thomas Kuhn's *The Structure of Scientific Revolutions*, 3rd ed., Humanitas Publishing, 2008.
67 Fama's term for rational agents is *sophisticated agents*.
68 The theoretical envy that economists feel towards the natural sciences (particularly physics) has not yet disappeared (e.g., the Black-Scholes-Merton formula is formally the solution to the heat equation in thermodynamics (Lo, 2019)).
69 Behaviourism, as a philosophy, was pioneered (in psychology) by Burrhus Frederic Skinner, in his paper *Behaviour of Organisms* (of 1938), rather as a radical behaviourism (behaviouralism) that completely rejected free will.
70 The specialty literature notes the following characteristics of an individual's economic behaviour that deviate (are anomalies) from the behaviour 'predicted' by the EMH: (1) over-confidence (Fischhoff & Slovic, 1980; Barber & Odean, 2001; Gervais & Odean,

2001); (2) over-reaction (De Bondt & Thaler, 1987); (3) loss aversion (Kahneman & Tversky, 1979; Shefrin & Statman, 1985; Odean, 1998); (4) herd effect (Huberman & Regev, 2001); (5) psychological accounting (Tversky & Kahneman, 1981); (6) probability miscalibration (Lichtenstein et al., 1982); (7) hyperbolic discounting (Laibson, 1997); (8) regret (Bell, 1982; Clarke et al., 1994; Lo, 2004).

71 The concept of human nature refers to the psychological and behavioural profile of the generic individual prior to the social contract, that is, to (as Martha Nussbaum would put it) the animality in man. Lo is beating much (perhaps too much) coin on this concept in justifying the functioning of adaptive markets at the expense of the functioning of 'rational' markets.

72 The genus homo is much older (about 1.8 million years), but the species *homo sapiens*, to which contemporary humans belong, split off (process of speciation) about 300 000 years ago (see Yuval Noah Harari's work, *Sapiens: A Brief History of Humankind*, Polirom Publishing House, 2017).

73 Natural selection refers to the biological evolutionary process of life and comprises two components (with circular causality between them): (a) the random component – genetic mutation; and (b) the directed component – cumulative natural selection by the environment (see Richard Dawkings's work, *Selfish Gene*, Publica Publishing, 2013).

74 Antonio Damasio said that, to be fully rational, we need emotion – see A. R. Damasio, 1994, *Descartes' Error: Emotion, Reason, and the Human Brain*, Putnam, cited in Lo (2019).

75 Before Kahneman and Tversky, Paul Slovic, referring to affect heuristics (or affective heuristics), said that negative emotion increases (as a perception) risk and decreases benefits, and positive emotion does the vice versa (Lo, 2019). The distinction between risk and uncertainty (to which we also referred in Chapter 1, drawing on Frank Knight's position on the matter) is of paramount importance from the perspective of economic choice. Thus, individuals make decisions under conditions of risk but hesitate to make decisions under conditions of uncertainty (see also Ellsberg's paradox: thinking is not the same as feeling), although uncertainty has its own mechanism for generating information, namely, Laplace's principle of insufficien reason (Ellsberg, 1961). Somehow, risk is the known unknown, and uncertainty is the unknown unknown.

76 In neoclassical economic theory, economic choice was stylized as a rational criterion: minimizing opportunity cost.

77 The term *representativeness heuristics* was introduced by Kahneman and Tversky (Kahneman & Tversky, 1972), while the term *heuristics* (heuristics is also known as *rule of thumb*) was introduced by Herbert Simon.

78 The concept of wisdom of crowds was introduced by Surowiecki (Surowiecki, 2005).

79 Crowd influence in choice is also known as the *herd effect*.

80 That the basis of economics should be biology was expressed as early as Alfred Marshall, and the foundation of all the social sciences on biology was also called for by the creator of the term and discipline of *socio-biology*, Edward Wilson (see his 1975 paper, *Sociobiology: The New Synthesis*). More recently, evolutionary psychology has been created as a reaction to Wilson's socio-biology which, taken too *ad litteram*, can lead to ethical dead ends.

81 The concept of rationality, from an efficien financial market perspective, is understood as providing the following two functions: (a) new information is included in the decision according to Bayes's rule, and (b) the choice is made according to Savage's concept: subjective expected utility (i.e., normatively acceptable). In this sense, behaviourism studies what happens if one or both conditions of rationality are relaxed. However, Sargent requires not only rationality but also consistent (i.e., non-contradictory to each other – our paranthesis) beliefs, which implies completeness of information (Barberis & Thaler, 2012).

82 Experience is, obviously, a sui generis mix between reason and emotion, because it synthesizes (and systematizes, i.e., justifies) *post factum* the emotion experienced by the individual in the choices he had to make in the past. It has also been shown that *ex post* rationalization/justification has a neuro-physiological basis (Kahneman and Tversky). This is where the so-called Pygmalion effect works (falling in love with one's own creation, as the ancient Greek sculptor Pygmalion fell in love with the statue he made).

83 See, here, the same distinction between sequential and non-sequential made between system 2 thinking and system 1 thinking, respectively (Kahneman, 2011).

84 For example, panicked behaviour can reverse the positive correlation between risk and return. Moreover, in the behavioural framework described by AMH, risk (i.e., risk-taking) is not always rewarded (Lo, 2019).

85 The original text is: 'If we want to understand current behaviour, we need to understand the past environments and selective pressures that gave rise to that behaviour over time and across generations of trial and error' (Lo, 2019; pg. 198).

86 The phrase was only popularized by Schumpeter because it was first used by the German sociologist Werner Sombart. Karl Marx also (without using the term) used the concept of *creative destruction*.

87 We repeat that AMH is opposite to EMH but not contradictory to it: on the contrary, one of the purposes (at least of a methodological nature) of AMH is to integrate EMH into its own paradigm.

88 We specify that EMH also has as a benchmark for evaluating the market efficienc also the balance generated by the demand-supply ratio. In fact, from a mathematical point of view, even optimization (extremization under restrictive conditions) takes into account, in the background, the whole balance. Obviously, it's about a balance to which it tends asymptotically.

89 We consider the two alternative financial market hypotheses to be relatively incommensurable (though not completely incommensurable because, in the latter case, the AMH could be 'suspected' of paradigmatic valence, which in our view is ruled out or at least problematic).

90 The idea that AMH is a generalization of EMH is, however, apparent several times in Lo's writings, particularly when he refers to EMH as frictionless AMH. Of course, AMH commentators have not missed Lo's position, and numerous articles devoted to this proposal take up the idea.

91 In the physical configuration (given by biological evolution) of the brain, from top to bottom, there are three stages of functioning: (a) the neocortex system; (b) the limbic system: emotions (*fight-or-flight* response); and (c) the reptilian system.

92 Neuroscience shows that fear is characterized by the fastest conditional learning: unlike other emotions, fear only needs one episode (one event) for fear to become (almost) permanently established about that episode/event.

93 That is, on the following processes: (a) competition, (b) mutation, (c) reproduction, and (d) natural selection.

94 The financial market is seen, in this context, as the environment in which economic behaviour acts (this environment encompasses both other economic behaviour – more precisely, other trading strategies – and the formal or informal regulatory framework of society).

95 The term used for such a situation is *innovation*, more precisely, behavioural innovation. In the AMH framework, a mutation will be understood as a re-establishment of the relationship between the rational and the irrational (it is obvious that the mutation will no longer be completely random, as in the case of genetic mutation, but will also contain a cultural component, whether deliberate or not).

96 Something similar also exists in Christianity: Saul of Tarsus (St Paul) said (in the First Epistle to the Corinthians) that if the resurrection of Jesus did not exist, then faith is in vain and the whole of Christianity is meaningless.

97 Finally (at the end of this study), we will depart from Lo's position of considering the financial market as the environment in which trading strategy evolves, for reasons that will be shown in due course.

98 See here, for example, the so-called sour grapes adaptive preferences discussed in Chapter 1.

99 In original: 'among the three P's of Total Investment Management, preference is clearly the most fundamental and least understood'.

100 This designation is, obviously, rather metaphorical, since the biological evolution of the individual is augmented (accelerated, directed) with an increasing weight of normativity (whether positive/legal or ethical/moral). Thus, if purely biological evolution is only genetically conditioned (thus mono-conditioned), cultural evolution in the field of economic behaviour is triple conditioned: (a) genetic, (b) memetic, and (c) semetic (see our considerations on this matter also given in Chapter 1).

101 Obviously, this is a possible translation, which we propose for the term *satisficing*, created by Herbert Simon, in the margin of his concept of bounded rationality, a term formed by combining *satisfying* with *suffice* – we propose *satisciency*. Of course, the problem of the benchmark to tell us whether the point of satisfaction has been reached (a problem that Simon also raised when he proposed the term) remains to be solved – however, in our opinion, this problem is easier to solve in the AMH than in the EMH. Moreover, this 'habit' of creating terms that combine two more or less consistent (i.e., non-contradictory) meanings is also present in the natural sciences – for example, following the Copenhagen interpretation (belonging to Niels Bohr) of quantum mechanics, wave and particle have been joined (terminologically) in the term *wavicle*, from *wave* and *particle*.

102 The three forms of market information efficienc are as follows: (a) *weak efficiency* – based on historical price information; (b) *semi-strong efficiency* – based on publicly available information; and (c) *strong efficiency* – based on all information, public and private, external or internal. As mentioned earlier, this typology was not introduced by Fama but by Roberts (1967).

103 For example, the interesting concept of the hypercycle (M. Eigen & Schuster, 1979).

104 Analogous to the well-known anecdote, let us consider two individuals who are chased by a ferocious bear (this is a variant we have reworked for the specifics of this study; here the bear is obviously the environment or the financial market). Looking back, one of them (an EMH economist pursuing the first-best solution) says worriedly, 'The bear is running faster than us, I'm very worried about how we might escape'. The other one (an economist who is an AMH supporter, pursuing the second-best solution) replies, 'I am not worried at all, because I can run faster than you'.

105 Here the term *normative* does not obviously have the meaning in the field of positive law but refers to the normativity exhibited by any theory, or model, or equation – it's about a cognitive normativity.

106 For example, in the AMH model, the risk premium is no longer constant but path-dependent.

107 There is also an alternative proposal to the AMH, which focuses on the impact of costs (of whatever kind) that matter in the economic choice (i.e., in the choice of trading strategy – thus, John Bogle proposed the Cost Matters Hypothesis (CMH) model (Bogle, 2005)). The essence of the proposition is: 'Gross returns in the financial markets minus the costs of financial intermediation equal net returns actually delivered to investors'.

108 Moreover, behaviourism shares with EMH the fact that it regards economic preferences as given in the individual's psychological 'dowry', without concern for the

mechanism by which they arrived in that dowry nor by the mechanism which they might be changed. Thus, from a methodological point of view, behaviourism and EMH are of the same type with respect to preferences, namely, they are conservative.

109 Here we remain, still, in Lo's theoretical framework, although later we will abandon the financial market as a selector of trading strategy, for logical reasons that will be fully explained in due course.

110 Probability matching (or, equivalently, probability overlap) is a concept discussed by Lo at length in his seminal work (Lo, 2019), showing a kind of rationality of behavioural deviations (deviations from the EMH), rationality validated by the approach of behaviour, evolutionarily, by the probability that events exhibit, in fact. In short, probability overlap refers to the tendency of economic behaviour to adapt to the environment (in our case, the financial market) or, rather, to the pattern of the environment. It should be noted that probability overlap is a systematic phenomenon, not an accidental one. This concept seems close to the one discussed by Kahneman (2011) regarding the tendency towards the mean of economic behaviour.

111 We will see later that this is co-evolutionary adaptation, which includes co-adaptation in evolution. An important aspect that will be used in the logical modelling of adaptive preference (not adaptive market!) will be that of *ex*aptation (as opposed to *ad*aptation): *adaptation* refers to the orientation of the function towards finality (purpose), while *exaptation* refers to the reorientation of the function towards the initial finality (purpose).

112 There are views that suggest that, at least in certain macroeconomic contexts (e.g., 'good' times in terms of investment opportunities or, more pointedly, momentum-type intervals when prices are rising), greed can dominate fear. If fear can be considered a signal to the individual, cost should be considered a signal to the market (hence Bogle's alternative proposal to AMH, mentioned in note 108).

113 Note that one of the objections to EMH (not only from behaviourism but even from the 'establishment') is that it does not allow (measure) degrees of market efficien .

114 The concept of information asymmetry was introduced by Grossman and Stiglitz (Grossman & Stiglitz, 1980).

115 By black noise is meant the state of the market generated by emotionally acting agents; they are the ones who ensure the gains/losses for sophisticated (rational) agents. In other words, market prices vary according to the relationship between emotional (noise-producing) agents and sophisticated agents.

116 The concept of *habit* is sometimes used in a broader sense (including normative framework, traditions, values, skills, dispositions, etc.), for which the term *habitus* is often used. *Habitus* contains the physical component, called *hexis*, and the mental component (see, e.g., Pierre Bourdieu's work, *Language and Symbolic Power*, Polite Press, 1991).

117 The expression seems forced (in any case, it is inconsistent with the idea that the irrationality of the agent's behaviour is the rational form of reaction to the changing environment, i.e., the financial market), because it implies the impossibility or unreasonableness of developing a rational model in the case of AMH.

118 As opposed to the classical view of convergence in market efficiency equilibrium

119 Example: the BDS statistical test for non-linearity of residuals.

120 Lo says repeatedly and in many papers that to beat a theory (such as EMH), you also need a theory – unfortunately, at least so far, AMH has not produced a theory either.

121 Preliminary considerations regarding the pair 'adaptant-adaptar' were made in Chapter 1 (see section "The concept of adaptation").

122 The concept of outcome has a wider (denoted) scope than the concept of output – while the output is an intentional (expected) output, the outcome also contains unintended outputs (by-products – spillovers – externalities, either positive or negative,

etc.). There are authors (e.g., Karl Popper) who argue that all economists need to do to ensure the predictability (and sustainability) of the economic process is to identify the unintended consequences of agents' decisions (but especially of public decisions). This, however, would require the elaboration of an economic theory of the unintended consequences of economic decisions (and behaviours). Standard economic theories, whether they are orthodox theories (see neoclassical economic theory) or heterodox theories (see institutional economics or, more broadly, evolutionary economics), deal only with intentional consequences.

123 To simplify this preliminary discussion, we still remain in the conceptual paradigm of AMH (which we will change, however, in the next chapter).

124 In fact, as we shall see, the problem in question is indeed a problem of symmetry in the 'group of state transformations' generated by the process of adaptation. For example, if a quantitative modelling could prove this symmetry to the point of constructing a prime integral (see the famous Noether theorem here), then a law could be formulated to preserve a representative parameter for the adaptation process, a law which could be the basis of a very strong predictive model, because it would be based on an invariance.

125 Unlike in the case of biological evolution, in the present case, the mutation is no longer random or completely random (see the model of behaviour on the financial market proposed by us: $RE^{(1)}E^{(2)}$), and the cumulative selection is no longer simply directed (by increasing biological fitness) but is partially teleologically directed. We will return in detail to these fundamental characteristics.

126 Lo does not explicitly say that preference (*Nota bene*: there are some reciprocal substitutions between desire and preference, but in our opinion, preference is closer to belief than desire – see also the considerations offered in this matter in Chapter 1) is adaptive, focusing on the fact that the market is adaptive, but another author, directly concerned with adaptive preference, states that preference (negligently equated with desire) is of the non-autonomous type: by non-autonomous character is meant adaptive character – it is about Jon Elster (Elster, 2017).

127 The number of degrees of freedom is given either by the number of dimensions of a space (if we are in the case of a geometric or topological approach) or by the number of parameters involved (if we are in the case of an analytical approach – algebraic or mathematical analysis).

128 There are authors (even among the most formidable) who consider that preference has no normative role in the choice. Of course, preference, being exclusively idiosyncratic, does not have a normative role in the sense of the positive (legal) norm but has a normative role in the more general sense of a pre-selection (so to speak); just like the normative role, in the latter meaning, it also has any model of rationality, or any equation or any per-locutionary statement (*Nota bene*: the perlocutionary statement – see, here, John Austin – is the statement that creates or has the potential to create reality, like the third world to Popper, of which that statement speaks, the perlocutionary statement being an act of speech). Amartya Sen is one of the authors who reject the normative role (or normative function) of preference (Sen, 1977).

129 The realized probabilities fall, of course, as they are observed, in the category of frequential probabilities, although, when they are estimated *ex ante*, they are of the Bayesian type. More rigorously, it is said, the Bayesian probabilities *a priori* (initial, based on which the choice was made) become Bayesian probabilities *a posteriori* (after the occurrence of the expected event). Bayesian probabilities are a kind of subjective probabilities (although they are adjustable as new information emerges, which conditions the initially given probability) – it should be noted that the distinction between objective probabilities and subjective probabilities was first made by Jacob Bernoulli. The further development of subjective probabilities owes much to Ramsey (1926), De

Finetti (1937), and Savage (1954) – provided that they satisfy the axioms of objective probability.

130 As we know (we referred to this earlier) inter-subjectivity is a kind of objectivity, namely, is the very objectivity of economic and social reality (what is also known as Popper's third world).

131 Here the concept or term of price has a generic denotation; it expresses the target/objective pursued by the economic agent through its financial market trading strategy – in this sense, this target can refer to any variable of interest for the agent; therefore the term *price* stands, so to speak, for the agent's target in the financial market.

132 Obviously, this would raise the issue of modelling a second-order cybernetic system in terms of adaptive preference (see brief considerations for this type of cybernetic system in Chapter 1, section "Topic VII: Co-evolution in adaptive preference").

133 Norbert Wiener, considered one of the creators of cybernetics (he was not the only one – one of the most important researchers in the field being Ross W. Ashby; regarding the chronological primacy of the invention of cybernetics, it is worth mentioning the contribution of (the ignored) Romanian scientist Ștefan Odobleja, from his work *Psychologie consonantiste*, published in 1938–1939 in Paris, in which he establishes the most important component of cybernetics: the law of generalized feedback), defined the new discipline as a theoretical study of control and communication in the machine and in the living organism (the title of his work, published in 1948 at MIT, is *Cybernetics: Or Control and Communication in the Animal and in the Machine*).

134 Biochemistry is an interdisciplinary approach, at the border between biology and chemistry, that is, in the territory of the origin of life. The fundamental concept here is that of the *hypercycle* (which could be 'borrowed' and successfully applied in economics, including in the study of the adaptive or co-evolutionary financial market – which the study will experience in its final part), introduced in the literature by Manfred Eigen (see *The Hypercycle: A Principle of Natural Self-Organization*, parts A, B, C, in *Naturwissenschaften* – in English, No. 11, 1977, and from the book *From Strange Simplicity to Complex Familiarity: A Treatise on Matter, Information, Life, and Thought*, Oxford University Press, 2013).

135 In the paper Froese et al. (2012) show that there are two logical models of the origin (and functioning) of life: (a) the *replicator-first* model and (b) the *metabolism-first* model. It is observed that both originate from genetic information. The authors 'ask' for another model to be considered, which they call *movement-first*. The term used by the authors is specific at the pre-cellular level (or, at most, at the molecular level), but a more general term, which we propose, in fact, could be the *behaviour-first*. It is (immediately) obvious that the role and function of preference in economic choice are rather compatible with this model called *behaviour-first*.

136 On the financial market (especially *entre connoisseurs*) works also *the exformation*: exformation means information that no longer needs to be transmitted in a communication, without, by this omission, reducing or prejudicing in any way its content or the meaning of the message. This possibility is ensured by the existence of a common fund of information/knowledge held both by the source of the communication and by its destination – for example, communication between lawyers or between dealers on the market is reduced (quantitatively) to a minimum. The famous example is, of course, that of 1862, by Victor Hugo, who, worried about the sales of one of his books (this is the novel *The Miserables*), writes to his publisher, '?'. The editor responds enthusiastically, '!' (Retvig et al., 1998).

137 Fitness, in biology (and, by extension, in economics) means a property of an entity's suitability (either living or institutional) to the environment in which that entity is 'submerged'. Adequacy refers to the exercise of functions and, therefore, to the achievement of the finality/purpos s of that entity. This adequacy is achieved by

adaptation-selection. Therefore, achieving the 'best' fitness is ultimately a process of mutual adaptation of the target entity and its environment.

138 Or the principle of action and reaction – when a body acts on another body with a given force in a given direction, the second body acts, at the same time, on the first body, with an equal force, in the same direction but in the opposite sense.

139 Although the concept of action is, usually, associated with the human agent (assuming a purpose, the allocation of means to achieve that goal and even a deliberation of the successive stages of the action in question (i.e., an anticipation/planning of them), here we ignore this aspect, and we consider taking action whenever a cause generates an effect.

140 The concept of force is defined by the second law of mechanics – the second principle: $\vec{F} = m \cdot \vec{a}$, where with F it was noted the force, with m it was noted the mass, and with a it was noted the acceleration (the arrow above symbols indicates that we are dealing with vector quantities, quantities that have a direction and a meaning).

141 For reasons of terminological unity, we will call the original action *act* and the subsequent action (*Nota bene*: here we have a logical subsequence, not necessarily or only chronological) *reaction*.

142 Using the first law of thermodynamics (the law of conservation of energy), the means of propulsion in outer space are based exclusively on the third law of mechanics.

143 Although we would rather propose another term to express the frame of reference we need, namely, the *response* term. However, although we always keep in mind the concept of response, we will continue to use, so as not to disturb too much the effort of reading the study, the reaction term but in the sense that we will define immediately.

144 In the economic field (and, more broadly, in the social field), the potential causes are, in fact, more numerous than the manifest (effective) causes – this includes, for example, all the anticipations that an economic actor makes when making a decision (we recall that the core of Minsky's critique of the neoclassical as well as the post-Keynesian economic model for their inability to analyse the internal causes of the instability of the capitalist economic system is based precisely on the feature of economic decisions in the market, either to be made or to be implemented – see his work, *How We Stabilize an Unstable Economy*, Public Publishing House, Bucharest, 2011).

145 Logically, it is not necessary to stipulate that this cause is generated by one individual and is supported (in the form of an effect) by another individual – it may very well happen that a cause has an effect on the same individual whose behaviour has generated that cause.

146 It should be noted, however, that in quantitative co-evolution models (see here Lotka-Volterra reaction-diffusion equations in the field of biology or biochemistry), *act* and *reaction* are concomitant or, in any case, linked by processes of circular causality having a necessary character (instrumental, this is done within a system of differential equations).

147 Obviously, the reaction precedes the act in the case, already mentioned, of anticipations. However, here we also can distinguish between adaptive anticipations (which may be subsequent to the act) and rational anticipations (which are always prior to the act).

148 This is the amount of action (or, equivalent, the amount of reaction) which is given, like any quantity, by the product between the intensity of the reaction and the duration of the exercise of that intensity. To give an example, personal income tax (quantity) is given by the product between the tax rate (intensive aspect) and the tax base (extensive aspect, equivalent to the duration of the intensive aspect).

149 The type of reaction called negative feedback is the opposite of the act; the type of reaction called positive feedback has the same meaning as the act.

150 For example, in the field of criminal justice, the commission of a crime of murder is not sanctioned (society's reaction) also with a crime of murder but with criminal imprisonment (*Nota bene*: there are, of course, states where the penalty for the crime of murder is also the murder, but this is an exception).

151 For example, someone who stole something from someone else will be punished for this crime by the competent state institutions, not by the plaintiff (if the plaintiff does justice to himself, he is liable to be punished by the state himself for a different crime).

152 Clock time is the mechanical, conventional time with which we operate in everyday life, that is, time independent of the process with which it is associated, so time with invariable tact.

153 Which has to happen, as the definition says, always.

154 It is the case, evoked earlier, of rational anticipations (or expectations – *Nota bene*: not to confuse anticipation with expectation: while anticipation results inferentially from a model of rationality, expectation is a subjective projection, a desirability, as a rule individually and much less frequently, and quite problematic, due to difficultie in aggregating preferences, community, or social group).

155 The institutional 'device' that ensures the automatic operation of this class of reactions is, however, introduced in the structure of the system involved also in a discretionary way, that is, non-automatic.

156 An example, here, could be the one that refers to the cross-price elasticity of demand. It should be mentioned (also regarding the Minskyan theory of economic instability) that the market cannot re-stabilize itself precisely as a result of blocking the substitution process, a blockage generated by the economic decisions of actors that are affected by time (financial speculation, financing and investment way, and others like that).

157 For example, accommodating employment to the fixed capital capacity that the economic system in question can activate. It should also be mentioned here that goods and services can be grouped not only by their potential for mutual substitution but also by their potential to be mutually assumed as a result of their complementary relationship – for example, bread and butter are complementary goods.

158 There is also the so-called problem of the first impulse (of the 'first fillip'), so we will consider, by convention, that the first act is a kind of unprovoked reaction. With the exception of the first act – which can come either from the adaptant or from the adaptar – all the other interactions are actual reactions. Of course, just as the first act is not a reaction, the last reaction is also not an act (the reasoning is analogous to that used in networks or graphs regarding the first node and the last node in the network/graph).

159 The sphere of admissibility is also called the sphere of *fetality* – by fetality is meant the property of a relationship (reactions) to be acceptable to the recipient (*Nota bene*: the meaning is perfectly similar to the content of the concept of fetality in the case of biological grafts).

160 It is expected that his behaviour, based on the prediction of the moment, has already been imitated by other agents who have observed the success of his strategy, so the space for the contrarian strategy has been freed up enough. To make a comparison outside the economy, in the game of football, a player maintains a direction and speed for a certain time and on a certain space on the field, so he attracts many players in his wake (equivalent to tracking the moment in the financial market), after which, suddenly, it changes its direction and speed, thus benefiting from the field space already freed by its followers and thus fulfilling its purpose in the game. Not coincidentally, the mathematical theory that has developed, both for economic competition and for economic cooperation, is called *games theory*. See also a paper dealing with this behaviour: (Handy, 2016).

161 The characterization of the adaptar (of the environment) as an individual is not (although it seems) forced. From the perspective of the co-adaptation relationship, both the adaptant and the adaptar behave as individuals. It would be much more difficult from a conceptual point of view, but especially from an instrumental point of view, for the adaptar (environment, or, more narrowly, the financial market) to be considered as a community comprising all the other economic agents besides the adaptant taken into account. In addition, the consideration of adaptar as an individual does not in any way restrict the generality and validity of the reasoning made.

162 The expression 'special character' has here its own meaning of 'character relating to the species' and not the meaning in the common language, of 'especially character', even if this character refers to an individual in a population.

163 It is easy to notice that this is about a normative cause (namely, the norm imposed by the structure) or, in Aristotle-ian terminology, a formal cause: the structure is the normative/formal cause of the function.

164 There is a 'mixture' here between the efficien cause and the material cause, but from the 'macroscopic' point of view (i.e., of the observer), only the efficien cause is relevant.

165 The formal cause is, as we have already shown, a normative cause (as it is – see the previous clarifications – an equation or an order/command).

166 The mutation in the economic field (thus, implicitly also on the financial market) is no longer random (as in the biological case) but is a combination between random and deliberative (more precisely, it is, in our opinion, a result of the modal filter $RE^{(1)}E^{(2)}$), we could say, according to Herbert Simon's 'technique' (see his concept of *satisficing* presented in Chapter 1), *randoberative* (from concatenation of terms *random* and *deliberative*). In this sense, it is worth mentioning that the specialty literature, even if it does not propose (yet) a term like *randoberative*, accepts that, in the economic field, for example, in the process of adaptation-selection of the organization (the problem also arises in the question of adaptation-selection of behaviour or trading strategy), there is intentionality (Lewin & Volberda, 1999).

167 A detailed discussion of the adaptation-selection relationship can be found in Baum (1996).

168 Predicatively, there is a crucial difference between random mutation and *randoberative* mutation, not only in terms of the nature of the mutation (one is completely random, and the other is a mix between random and intentional) but also in terms of the transport 'vehicles' of the mutation: thus, in the case of the random mutation, the vehicle is the *gene*, while in the case of the *randoberative* mutation, there are two such vehicles: *meme* and *seme* (see Chapter 1 for details on this subject).

169 Many analysts (or article writers) omit to add the *cumulative* predicate to the term selection, although both biological and economic (or financial) evolutions are impossible in the absence of the cumulative (in the simplest case, the additive one) character of the selection. Of course, we have (both in biology and in economics) the so-called punctuated equilibrium (conjecture proposed by Stephen Jay Gould and Niles Eldredge) (Gould & Eldredge, 1977), but this is the exception rather than the evolving rule.

170 In the final logical model, which we will propose, the degree of specialization will be one of the constraints that will be considered as a rigid constraint (as opposed to flexible constraint), that is, a structural constraint.

171 However, there are also authors who consider co-evolution as semantically equivalent to co-adaptation (Ehrlich & Raven, 1964).

172 It could, however, be the subject of a study such as a scientific article on adaptive preference (or even Lo's adaptive markets) – for example, the European single market would successfully illustrate the concept of multi-scalability.

173 Syntagma 'future event' in the context of probability allocation is not pleonastic, as it would seem *prima facie*, because *a priori* Bayesian probabilities can also be

assigned to past events: for example, in cliometric (or cliodynamic) analyses, the analysis against factual must operate with probabilities assigned to past counter-factual events.

174 Not to be confused with the concept of statistical moment as a static (state) property of a time series (e.g., the first order moment is the mean of the series, and the second order moment is the series variance) with the concept of statistical moment as kinematic property (flo , or trajectory) of the series: positive correlation between the values of the variable of a series, over a certain time interval, correlation that defeats the random walk. The possibility of this confusion can be ruled out if, for example, the term *moment* in the second sense would be replaced by the term *inertia*, which is even more suggestive.

175 It must be said that there is another concept of waiting (which uses the whole term *waiting*) in what is called the theory of waiting (or the theory of queues), in which waiting has the meaning of the time elapsed since the 'queuing' of an individual and until serving the purpose for which that individual sat in line. In this case, waiting is also a mathematical species, so non-subjective.

176 As in other cases, English terminology can be misleading – the term *expectation* has, here, rather, the meaning of anticipation/anticipate (as in Muth's work – see Chapter 1 – which introduces the concept of rational 'expectation' using the term *expectation*). The ambiguity is explained by the fact that, in English, anticipation is almost synonymous with prediction, which is why the term *expectation* is preferred.

177 Someone with an exaggerated sense of nuance may consider that the preference is the praxiological manifestation (either by act or by abstention) of belief, that is, its objectification. The relationships among belief, desire, motivation, interest, and preference are, of course, of the greatest significance, but they will be resumed in the right place.

178 One can, of course, gloss here for a sui generis parallel between the two systems of thought proposed by Kahneman (*Nota bene*: Kahneman is not the 'inventor' of the terms in question, but Keith Stanovich and Richard West are); fast thinking, slow thinking, and the concepts of waiting, as well as anticipation, in the sense that waiting would correspond to fast thinking (system 1 in Kahneman's terminology) and anticipation would correspond to slow thinking (system 2 in Kahneman's terminology).

179 The *win-win* economic game is what is called a positive sum game (the sum of the partners' winnings, resulting from the *win-win* cooperation, is higher than the sum of the winnings at stake for the two partners) – a peremptory example of positive synergy, as we will see later.

180 This situation, which is not uncommon in the economic process, is called the *Queen Hypothesis*: the extinction of one species following competition with another species, due to the fact that common fitness remains constant, that is, remains on a curve of indifference, being therefore a trade-off of interspecies fitness (the exotic name comes from the analogy that can be made with a game played by the queen in *Alice in Wonderland*, Lewis Carroll's logical-fiction book) (Lewin & Volberda, 1999).

181 Obviously, from a theoretical point of view, any *loss-loss* game can be hijacked/corrupted to a *win-loss* game, if the total loss of substantive utility is so distributed among the partners that one of them, in fact, either wins or remains on a curve of indifference from the perspective of the substantive utility held at the end of the game.

182 In a more sibylline expression: reducing the length of moments.

183 Beliefs themselves are primitive, that is, they have the value of principles, and they are self-founding (they do not need a principle, even more primitive, to justify them). More generally, a belief is a device (most often or most part, being subconsciously) for a-rational justification of preference.

184 Group selection should not be confused with inter-species selection (we will return to inter-species selection at the end of the research, when we will discuss, in detail, the issue of self-poieticity).

185 The difference between development and evolution consists of two components: (1) development refers to the individual, while evolution concerns the species; and (2) development involves only the mutation at the level of the individual, while evolution involves, in addition to mutation, the cumulative selection of the environment on the individual (phenotype). Of course, in the context of the financial market, the individual will be understood, as the case may be, the preference, or the trading strategy, or, still, the individual transaction.

186 We emphasize the fact that, as with the biological case, fitness is not selected (fi - tered) by the environment according to a criterion of maximization, but according to one of adequacy, that is, from the perspective of survival, not from that of optimization. In fact, this confusion lies in the non-testability of EMH, although, as we have shown, it is 'tested' daily tens or hundreds of times by zealous econometric writers of articles.

187 We mention the way in which the mutation occurs, in the biological field, at the two levels: (a) at the micro level: by transcription errors from DNA to m-RNA (following that m-RNA – messenger RNA – to be transcribed further in the synthesis of protein); (b) at the macro level: by the effe t of physical, biological, or chemical factors of impact (e.g., radiation) on the genome.

188 We remind you that, by *punctuated equilibrium*, we mean a non-cumulative, sudden selection (from a geological perspective). This meaning is valid in palaeontology (where this concept appeared), but from the perspective of the financial market, it must be adjusted under the influence of culture, which we will continue to do.

189 While in nature it is extremely rare, its frequency being calculated in geological time units.

190 Neoclassical economic theory (in fact, from this point of view, it is inspired even by classical political economy – Smith, Ricardo – which argues that selfishness is a necessary condition for the progress of society (including economic progress)). *Nota bene*: but also, a condition of sufficienc in this respect. Libertarians (e.g., Hayek) argue the same thing. Let us remember, here, that the *homo œconomicus* model, on the basis of which EMH was built (and, by the way, Samuelson's martingale), is a model that retains as a criterion of behaviour of the individual precisely the selfishness.

191 'Act that you use humanity, whether in your own person or in the person of any other, always at the same time as an end, never merely as a means' (Wright, 2002).

192 In the direct instrumental sense, each of us always treats others as a means – for example, when an employer hires an employee, or when we 'use' a baker to buy a loaf – but the Kantian maxim requires that, even in these circumstances, let us not forget that every individual must be seen as a goal and never just as a mean.

193 Conventionally, although not generally accepted, the 'beginning' of history is considered the 'moment' when hunter-gatherers invented agriculture and changed their survival behaviour as such.

194 On a large scale, we can mention colonialism; on a medium scale, we can mention the 'obese' public sector in a state; and on an individual level, we can mention the behaviour of some children towards their parents.

195 Which should cause EMH to simply turn into AMH. Unfortunately, as we said earlier, AMH does not provide a theory of the financial market, just as BMH does not offer one, while EMH has such a theory.

196 There is, however, a distinction between symbiosis and *win-win* cooperation: while the first has a necessary, non-voluntary character, the latter has a contingent character (in the case of humans – a deliberate character).

197 In other words, positive synergy generates positive feedback on the preference which has caused the synergy in question.

198 We note that any preference is adaptive (under the same considerations as to say that any evolution is a co-evolution), despite the fact that some economic models (including EMH) consider them given and immutable, at least in the exercise of the models in question.

199 The emergence would represent, in this case, the actions of uninformed agents (or, in Fama's terminology, unsophisticated).

200 In essence, generalized Darwinism introduces an evolutionary theory group selection (according to some authors, also oblique selection, i.e., inter-species) (Essletzbichler, 2012).

201 A handy example here is the banking system: a super-specialized bank has, on average, higher profits than a universal bank, but in the event of a financial crisis, the universal bank does better than the specialized bank.

202 And, by the way, with the physical 'order' in which our brain has evolved: by adding new layers of connections (or increasing awareness), in a non-optimal way and even unsightly (Searle, 2004).

203 Logically, an institutional variation (change) acts as a restriction (the restriction can be both positive – the extension of the 'law of motion', which can be called institutional relaxation – and negative – the restriction of the 'law of motion', which can be called institutional constraint). The role of the norm/law is therefore one that concerns the sphere of choices available to the agent (in our case, to the economic agent or, more importantly, to the agent trading on the financial market): therefore, institutional change is a mutation (produced in the environment/market which must be accepted (or rejected, as the case may be) by the agent.

204 We recall that, conceptually, there is a difference between dynamic systems and kinematic systems (a difference that should also be respected from a terminological point of view): kinematics studies the variation of a system itself, without caring about the causes of those variations (e.g., studying the variance or stationarity of a time series), while dynamics studies this variation taking into account the causes that determine it.

205 The deterministic predicate and the analytic predicate are logically equivalent: they mean that a law of motion, established for a population, applies identically to each individual in that population. As is well known, statistical mechanics (or thermodynamics) tried (through Ludwig Boltzmann, in particular) to extract the macroscopic from the microscopic, that is, by aggregating the analytic into statistics (obviously preserving causality). Niels Bohr did the same when he developed the Copenhagen interpretation of quantum mechanics. Numerous attempts to extract macroeconomics from microeconomics are also known in economics – (Bergh & Stagl, 2003).

206 In this sense, the so-called population genetics has been developed, which studies the frequency of occurrence of a mutation in a population, through the predominance of an/some allele (s).

207 It should be noted that, although he calls his own model as AMH, Andrew Lo treats, in fact, not the adaptive market *per se* but the tandem of trading strategy – market (financial) and, as we understand, also from a co-evolutionary perspective. However, while Lo emphasizes on the 'choice' that the financial market makes over trading strategy, we emphasize the variation in preference.

208 A logical model is often called a paradigm, although rigorously and in the Kuhn-ian tradition, a paradigm is not exactly a logical model but a way of producing knowledge – usually scientific – which, for this purpose, contains, necessarily, one or more logical models (or theories) subsumed to that way of producing knowledge (in Kuhn's terminology, subsumed to that way of doing normal science).

209 Which is about homeorhesis rather than homeostasis.

210 Syntagm *representativeness heuristic* was introduced by Kahneman and Tversky.

211 It is the strongest principle that behaviourism (BMH) opposes to the theory of rational expectations (EMH) and on the basis of which most criticisms have been

made of EMH (this principle is also at the origin of most 'anomalies' – many of them, of course, are false anomalies (see the myths related to the falsification of EMH, in Chapter 1)).

212 We also specify the following: next to the sphere of admissibility (S), there must also be spheres of acceptability (A), spheres of observability (O), and spheres of controllability (C), because the system consists of the adaptant and the adaptar, that is, the system $\Phi(a, A)$ is a cybernetic system, or a second-order cybernetic system (as shown in Chapter 1, the second-order cybernetic system contains the observer/regulator itself, as opposed to the first-order cybernetic system in the case of whose observer/regulator is outside the system in question). In context, we have the following sequence (or filtering, in the language of financial mathematics – see, for the notion of filterin , the concept of martingale, more precisely, the measurable spaces in a probability space): $C \subset O \subset A \subset S$.

213 The problem is similar to the choice of axioms in the design of a theory – the choice is entirely discretionary, if not frequently arbitrary (respecting, of course, the logical principles involved).

214 Such an ordering number would count as a relevance number (analogous to the utility number), either cardinal or ordinal (*Nota bene*: our opinion is that it should be an ordinal number).

215 Of course, the whole discussion related to the regression *ad infinitum* must be resumed in connection with the choice of the rationality model.

216 Consequentialism is, in epistemology, one of the theories of justification – for example, Rawls's theory of social justice can be described as a consequentialist theory, because the choice of the basic principles of society (in the original position in which the social contract is 'signed') given the consequences (potentially equal, in this case) that these principles will have in society, once chosen. Another example can be found in economics: the criterion of choice in neoclassical economic theory (hence, implicitly in EMH) is the maximization of the expected utility, that is, a consequence (cardinally measurable, in this case) of the choice made. Also, consequentialist is (in philosophy) the pragmatism of William James: what is successful must be considered true, that is, what produces the expected results.

217 *Homeorhesis* is the dynamic analogue of homeostasis, that is, while homeostasis ensures the preservation of the state of a system, homeorhesis ensures the preservation of the trajectory (flow) of that system.

218 Regulatory principles ensure both control and command of homeorhesis.

219 And not on statistical-rational representativeness.

220 The distinction between causality (or causation) and conditionality (or conditioning) is not non-problematic. After all, if a cause has no effect unless a certain conditionality is present, should we not regard that conditionality as having a causal role? This would lead us to the concept of causal complex (which also includes the 'standard' cause and conditionality), but, through a proper aggregation, the causal complex is simply the cause. On the other hand, as is well known, the cause is sufficien for itself to produce the effect. So, if it can be shown that a particular cause has the full potential needed to achieve the effect, is it still justified to introduce conditionality into what we have called the causal complex? Our view is that causality must be separated from conditionality, and we bring here an argument in the field of social justice: to admit that merit is the cause for which remuneration is received (e.g., a share of GDP, such as wages). But if the merit does not have the economic opportunity to manifest (e.g., there is no job), then the merit cannot be remunerated. Therefore, a conditionality is needed – the existence of a job, in this case – which is not, in turn, the cause of remuneration but only an opportunity for it. Or let's take an example from the tax field: there is an obligation to pay personal income tax if this income exceeds a

certain level. The cause of the tax payment is obviously the existence of the tax norm which is stipulating this obligation, but the obligation does not become eligible if the level of personal income remains below the established threshold (therefore, if conditionality does not occur).

221 Here is a problem (for which a solution must obviously be proposed) – it is about the concept, introduced by Jon Elster regarding adaptive preference, namely, the concept of *sour grapes* (Elster, 2017). The preference adapts, in this case, 'down'; in other words, the catalyst in question seems to act in the non-performing direction.

222 This predicate is one of the most significant in terms of the concept of catalyst – the fact that a catalyst is non-autonomous immediately leads to the idea (present, in fact, in biological and physiological theory – see the case of 'intelligent' enzymes (Monod, 1972)) of the selection or selective capacity that a catalyst can exhibit. From here to introducing the catalysts into the logical model of adaptive preference are not too many steps to take, and we will go through these steps.

223 Andrew Lo says even more in this regard, namely, that to 'beat' one theory (he refers to EMH), another theory is needed (Lo, 2019). Of course, the author 'modestly' hopes that AMH will be exactly that theory (in our opinion, this hope is a bit hasty).

224 Conceptually, the hypercycle is an application of Darwinism at the molecular level (Jerman, 2016).

225 We resume the observation that here we are dealing with a violation of Popper's position on the variation of the probability of the truth of a theory/hypothesis in the case of successive corroborations (as, e.g., the case of quantum mechanics, or generalized relativity) – while Popper argues that, in accordance with his theory of factual falsifiability, the corroboration does not alter (in any case, does not increase) the probability that the theory/hypothesis tested is true, in the case of self-catalysis working on preference, it seems that, from a psychological point of view, the belief in the 'truth' of preference increases as its testing has led to success in the financial market. As we said at the beginning of Chapter 1, we are simply dealing with the increased probability that the preference will choose, over and over again, the strategy that has not failed until then. This is, as we said, a self-catalysis.

226 For example, the concept of the *invisible hand* acts through hypercycles generated by the reciprocal actions of free economic agents.

227 The concept of hypercycle is also used in other fields. For example, in hyperbolic geometry (i.e., non-Euclidean geometry in which the axiom of parallels says that at least two parallels to that line can be drawn from a point outside a given line – this geometry is also called *lobacevskian* or *bolyai-lobacevskian geometry*; non-Euclidean through which no parallel can be drawn to a given line through a point outside that line is called *elliptic geometry*), the hypercycle is the curve whose points have the same orthogonal distance to a given line, called the axis (the hypercycle being, in fact, in this case purely geometric, a sphere).

228 We repeat that there is no bijective relationship between preferences and trading strategies; a preference may correspond to several trading strategies, and a trading strategy may be based on several preferences (which are obviously consistent with each other).

229 We specify that in the economic modelling, there are no formalizations of the hypercycle, in the context of the Eigenian concept, and, of course, it is even less formalized for the case of adaptive preference.

230 And here, unfortunately, confusion in many 'scientific' articles abounds. It says, for example, 'this one received feedback from this one.' This type of 'feedback' is a simple answer (as we will see, it falls into the category of reaction rules that we talked about earlier).

231 From a theoretical point of view, things are more nuanced. Thus, feedback is defined as a closed control signal, that is, a signal that is dependent on the output of the

system in question. In this sense, the feedback could also come from the environment, if it depends on this output. There are also open control signals, which are autonomous (or independent) of the system output (the latter come from the environment or may even come from the system but without being dependent on the system output).

232 Not to confuse the stability with the stationary: negative feedback ensures stability, that is, oscillations are allowed in the pre-accepted tunnel of variation, provided that the variation does not come out of the tunnel, while the stationary involves, so to speak, a point stability, not a tunnel (or interval) one.

233 Negative feedback is also known as degenerative feedback.

234 Adapted to our research topic, it refers to the increase (around a certain threshold, considered critical) of the share of certain trading strategies in the total trading strategies (or, according to the perspective that will be instrumented by the research team, of the share of a preference (s)/beliefs in the total preferences/beliefs operating on the financial market).

235 Of course, reference will be made to the causal/conditional relationship between preference (or belief) and trading strategy (which we have already referred to in the main text). In this sense, the change in preference may lead, beyond a certain threshold of variation, to the impact on the choice of trading strategy, but this relationship is non-linear and non-invariant.

236 We specify that the term (and the concept of) *compartmentalizing* does not have the specific meaning of biology or biochemistry studies but rather the 'civil' meaning of relative separation from a functional point of view.

237 Here, as we said, we 'break away' from Lo, who considers the financial market as the environment of trading strategy.

238 The 'mechanism' of this transfer is to change the relative pricing between the two sectors/domains, or, more precisely, to change the opportunity costs of the decisions involved.

239 Deregulation is obviously a kind of regulation, just as economic decline is a kind of economic growth, and disinflation is a kind of inflation

240 In principle, the move from meme to seme is referred to as regulation, while the transition from seme to meme is referred to as deregulation.

241 The concept of quasi-species is introduced by Eigen and Schuster in connection with their theory of the origin of life, more precisely in connection with the hypercycle mechanism in the pre-biotic self-organization of nature (M. Eigen & Schuster, 1979).

242 From a theoretical point of view, we cannot avoid, here, the parallel with the concept of representative agent, used in logical and quantitative microeconomic modelling from standard (textbook theory) economic theory: indeed, if transactions as such are considered individuals/point agents (at limit, idiosyncratic), then the trading strategy will simply represent the representative agent (or representative individual) for those transactions. We draw attention to a possible confusion: representativeness is considered only at the level of a given trading strategy, that is, a certain trading strategy is the representative transaction (or the average transaction) but not at the level of all representative strategies. Thus, if we want to build a representative trading strategy, we will have to calculate an average of all trading strategies operating in a financial market, that is, to average the averages (as we know, from a statistical point of view, there is the concept of average of averages – as, moreover, that of averages of other statistical indicators such as statistical moments. *Nota bene*: not of the type of fina - cial moments in the time series, although the same term of moment is used).

243 From a methodological and instrumental point of view (although, obviously, not from a conceptual point of view), it is not advisable, in our opinion, to consider physical individuals as individuals of the 'population' of the financial market (in fact, Fama or Lo does not do so, either explicitly or implicitly).

244 For example, by sympatric or allopatric evolutions (discussed in Chapter 1).

245 It is noteworthy that Lo (the creator of AMH) considers that the selection of trading strategies is made by the financial market. It follows, therefore, that Lo considers individuals to be indeed trading strategies, just as, at the firm level, individuals are considered to be routines (Nelson & Winter, 1985), which we also accept. But in this case, which species is evolving (or co-evolving)? It cannot be the market, because, being the court of selection, it is, of course, the environment. So, in Lo we have the individual and the environment, but we have no species. The trading strategy cannot be considered a species for the transactions that fall under its incidence (and which, thus, would become individuals for the strategy), because the selection court does not select the individual transactions but the strategies. These logical difficultie (and adaptive and evolutionary mechanism) are overcome if our suggestion that the market represents the species is accepted, so it is not the court of selection.

246 We give two examples of *punctuated directed selection*. The *first* refers to the emergence of financial crises (*Nota bene*: we repeat that any crisis in the economy is a financial crisis, i.e., it occurs in the financial/nominal economy, although, through side effects or induced ones, it can turn into an economic crisis – i.e., it can affect the real economy) which upsets the entire logic of the functioning of the financial market, including the process of targeted selection. The *second* refers to sudden and massive changes in the constraints of trading strategies – the emergence of new financial market models, such as EMH, or the emergence of instruments/techniques, such as the Black-Scholes-Merton technique of financial derivatives or the emergence of normative type constraints, such as changing capital requirements in the banking system.

247 It is to be examined (in an independent research direction, however) whether, in terms of the selective acceptability (so to speak) of trading strategies, propensity probabilities can be used as *markers* of this acceptability.

248 Obviously, the fitness concept of a trading strategy must be defined and, as far as possible, measured. In our opinion, this concept is crucial in developing a realistic model of adaptive preference and, further, in developing an autopoietic model of the financial market hypothesis (APMH – *Autopoietic Market Hypothesis*) as intended by the research undertaken.

249 In our opinion, it is strictly about the nominal economy, not the financial one, but such a distinction (a little too analytical) does not add value to the analysis intended here, so it will only be operated as a marginal observation.

250 The echo of the concept of normal science in Kuhn's paradigm theory (Kuhn, 2012) is easy to see: routine is what the firm does and what the firm expects to do next – the same is true for normal science, except that in the case of routine, we are in a praxiological paradigm, while in the case of normal science, we are in a cognitive paradigm.

251 The presumptive idea (which we can possibly introduce here, just for the sake of discussion), namely, that the trading strategy evolves, leads to a contradiction: if the trading strategy is the individual, then it does not evolve but develops, and if the trading strategy is the species, then it is not selected, because the selection always targets the individual.

252 From a theoretical point of view, the relationship between belief and preference must also be discussed – the question being: what is belief, from an evolutionary perspective, in relation to preference, if the latter is, as we want to say, the genotype? But the research needs in this study do not go that far.

253 Review our concept of *randoberative*.

254 A question could be put here: in the animal realm, when hunting, some species act in the pack (e.g., the wolves), while other species act individually (e.g., cheetahs). Really, do the two species have simply different models of rationality? Again we must appeal the anchor of consciousness: we can speak about models of rationality only when such models are conscious. In the case of animals, the instinct, adapted

to the environment, led to some specific models of behaviour but not to models of rationality.

255 Obviously, our approach departs from the historical/sociological approach used by Kuhn, so it is much closer to a logical one.

256 To be noticed that, here, the term *nucleus* does not hold the semantic sense of Lakatos nucleus/hard core, so it is one of the components of research program, alongside hypotheses and negative and positive heuristics (Lakatos, 2012).

257 The finality is more general than the purpose – the purpose is the conscious finalit .

258 Rationalization is a justificati n based on a model of rationality. Although, principled, rationalization occurs before decision and action (by a valid inferring of that decision from the model of rationality concerned), behavioural psychology has shown that, frequently enough, the rationalization occurs after the decision is taken or the action is performed (see, also, the Pearl Harbour effect).

259 The third world of Popper (the objectified inter-subjectivity) should be considered as an object, likewise the first world of Popper. So, it remains that the subject is the second world of Popper. The three sorts of fundamental human activities are, obviously, of Kantian origin.

260 The well-known Kuhn-ian paradigm is of this cognitive type.

261 By conceptual symmetry with the syntagm 'Minskyan moment', the latter addressing a (predicted or unexpected) serious collapse in the asset prices on financial markets.

262 Some authors go even further and identify also other 'paradigms' in the financial markets: Theory of catastrophes, Coherent Market Hypothesis, Prospect theory, Theory of random walk, Theory of fractals, Chaos theory, and so forth (Malyshenko et al., 2019). It is obvious that such a sphere of 'population' of paradigms is too comprehensive because there is not a clear criterion to extract the paradigms from all models regarding the financial market.

263 The concept of anomaly, as it is assignable to a paradigm, was systematically used by Thomas Kuhn (2012) in 1962 (first edition of *The Structure of Scientific Revolutions*), and for financial realm, especially from the behaviourism perspective, it was coined by Robert Shiller (1981).

264 To be mentioned, however, that no anomalies can be detected as such inside a given paradigm. To detect them it is needed for the challenging new paradigm, even in an incipient state, because the anomalies are always paradigmatically closed (here, paradigmatical closing is similar to Heisenberg's concept of theoretical closing).

265 In Kuhn's view, not the quantity of anomalies claim a new paradigm but rather the 'quantity' of researchers in the given scientific community who believe the anomalies cannot be tolerated anymore. Although Kuhn himself does not identify here an issue of populational selection, it is clear enough that this is the situation. In fact, the new paradigm is simply selected through selection of the researchers who do not accept the anomalies.

266 The period in which the anomalies are considered, either as old or as new anomalies, is termed by Kuhn as an extraordinary science stage.

267 See note 266.

268 The debate on the economic anomalies has been introduced by Michael Jensen, in 1978, while the debate on the financial anomalies (i.e., anomalies on the financial market) has been introduced by Richard Thaler, in 1978 (Gilbert, 2011).

269 In other words, the financial market (likewise as any social realm) is a cybernetic system of second order.

270 Probably, Soros was, here, influenced by Maurice Allais's considerations on the refle - tion: individuals overestimate the certain results and underestimate the probable results – *Nota bene*: such considerations are of importance also for Kahneman's prospect theory (see Maurice Allais, Le Comportement de l'Homme Rationnel devant le Risque: Critique des Postulats et Axiomes de l'Ecole Americaine, *Econometrica*, *21*, 1953).

271 In fact, the gain from financial market is provided by the (well-predicted) gap between price and value regarding a given security, based on which, sometimes (but not always) and by someone (but not by all), the market can be beaten.

272 See note 263.

273 We do not know studies that refuse the paradigmatic status to EMH. Even Lo, in his remarkable essay to go further from EMH, calls it as a paradigm when he discusses 'the traditional investment paradigm' (Lo, 2019).

274 This assertion cannot be generalized to all social sciences because they can be also of practical type of paradigm. On the other part, the so-called humanistic sciences are separated from both economic and social ones since majority of them enter the theoretical sciences.

275 To be noticed that the action is a genus with two species: (a) *to act* – that is, to do; (b) *to abstain* – that is, not to do. On the financial market, to abstain could be, often, at least of the same importance (relevance, impact, etc.) as to act – for example, even in EMH framework, if available information is not used in actualizing the action (namely, to initiate, change, or stop it), the price does not integrate that information. In our opinion, in fact, it is not the information that drives the behaviour but the behaviour that drives the information (in such conjecture, we should better talk about behaviourally market efficienc instead of informationally market efficien , as EMH does). See an interesting conjecture about the primacy of behaviour over the information in T. Froese, T. Ikegami, and N. Virgo, *The Behaviour-Based Hypercycle: From Parasitic Reaction to Symbiotic Behaviour*.

276 Here, in David Lewis's meaning, that is, as a primitive (unjustifiable) propensity (or preference, although without a complete semantical overwhelming), as this term (of credence) is used in introducing his concept of principal principle (see David Lewis, *A Subjectivist's Guide to Objective Chance*, *Studies in Inductive Logic and Probability*, vol. 2, University of California Press, 1980).

277 For example, Samuelson's martingale (the stochastic process of the 'fair game' – more than the simple random walk) leads to the same result: efficient market

278 We remind to the reader that a puzzle question is a question that is noticed only inside the paradigm, and its solution is a particularization of the exemplar solution of that paradigm. For example, in EMH case, an exemplar solution is one that gets the market (informational) efficien .

279 In fact, the disciplinary matrix is the very device of conservation process of the (normal science of the) paradigm.

280 Much more seriously, there are opinions according to which even the neoclassical economic theory (consequently, both *homo œconomicus* model and EMH) is not (factually) testable – such a conclusion is based also on an application of Gödel's theorem on incompleteness of an axiomatic system, as neoclassical economic theory is, in fact (see, here, Velupillai, K. (2005), The Unreasonable Ineffectiveness of Mathematics in Economics, *Cambridge Journal of Economics, 29*(6), 849–872).

281 Behaviourism in economic field is massively feeding with results obtained in neuroscience, including cognitive and behavioural psychology.

282 Of course, in a (possible) development which exceeds the paper's objective, such a relationship could be treated either deterministically or stochastically – in the latter case, α and β will be viewed as probabilities (frequential, or Bayesian, or even propensities) verifying Kolmogorov's axioms.

283 One could say that the artific al intelligence can extend the component R over the other components ($E^{(1)}$ and $E^{(2)}$, respectively). We do not agree with such a perspective, because, as AMH claims, the biologic delay of the human being related to the institutional development of financial market will always hold the E as active.

284 Obviously, the term *behaviour* used here has no connotation linked to behaviourism (or behavioural finance).

285 In fact, here we replace the predicate of rational, of EMH, with the conjunction of two new predicates, consistent with value of heuristic, namely, attentive and reflective. It is obvious that the two proposed predicates for the economic agent under AMH are in line with the biological and evolutive base of Lo's theory.

286 Of course, searching the maximin second-best solution does not mean that individuals optimize but that such a searching is, somewhat, natural, being inferred especially from $E^{(1)}$ component of our trinomial $RE^{(1)}E^{(2)}$.

287 Of course, the trading strategies are, in turn, suffering an adaptation since the new strategies will try to work somewhat likewise as the succeeded strategies. We have here the so-called mutual adaptation (with some conceptual precautions, in fact, we have a co-evolution process).

288 Populational selection is a kind of sympatric selection or speciation.

289 Maybe a more appropriate syntagma would be *practitionary matrix*.

290 Methodological suggestion: by applying spectral analysis (which identifies both the probability distribution of the signal amplitude and the *power spectral density* or only power spectral). Recall that there are, in this sense, nine colours associated with noise, classified according to the spectral power $S(f) = 1/f^{\alpha}$, where f is the function of the signal frequency, namely, *black*: $3 < \alpha < 9$, with indeterminate amplitude probability distribution (*Nota bene*: it describes especially rare events or black swans); *grey*: α is in the sonority norm, with indeterminate amplitude probability distribution; *brown* (or Brownian noise: $\alpha = 2$, with indeterminate amplitude probability distribution (*Nota bene*: it describes the Brownian motion or Wiener process, also known as random walk); *red*: $\alpha = 2$, but the amplitude follows a non-Gaussian probability distribution (*Nota bene*: it mainly describes astrophysical processes); *pink*: $\alpha = 1$, probability distribution of the bounded amplitude (*Nota bene*: it describes processes with self-organization – such as, in fact, economic or financial processes; pink noise is more suitable for the financial market than white noise); *white*: $\alpha = 0$, bounded probability amplitude distribution and linear frequency function; *green*: $\alpha = 0$ or $\alpha = 2$, probability amplitude distribution bounded; *blue*: $\alpha = -1$, probability amplitude distribution bounded (*Nota bene*: it is used for the case of discretization/quantification of continuous processes); *purple*: $\alpha = -2$, probability amplitude bounded distribution (*Nota bene*: it is used for artificial intelligence processes) (Doyle & Evans, 2018).

291 In standard topology (spatial, geometric), topological equivalence refers to form. Probably, in a temporal version, the topological equivalence could target the rhythm (rate) of change. From an instrumental point of view, tensor theory seems to be the most appropriate, because it captures invariants.

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3 A (stylized) modelling of adaptive preference

Propensities

Preamble

The equational model of adaptive preference must reproduce, in an isomorphic way, the logic model that was elaborated and examined in Chapter 2 (these constraints will be developed analytically in sections "Analysis of assumptions" and "The mix information-behaviour on the financial market"). As far as possible, the equational model will include quantitative variables[1] designed to provide an operational mechanism based on empirical data, concerning the dynamics of adaptive preference on the financial market. In Chapter 3 we will depart from Lo's approach (from the point of view of the 'target') – he examines the adaptive (financial) market problem; we will focus on examining the adaptive preference[2] problem on the financial market. Of course, the suggestions that can be found in Lo's work (and in the subsequent Adaptive Market Hypothesis (AMH) proposals elaborated by proponents or critics of this hypothesis) will be used, *mutatis mutandis*, by us as well, but as we shall see, the focus of our approach is quite different. The analytical/formal development of the mechanism of adaptive preference in the financial market will lead us, we hope, to lay sufficien foundations for the elaboration, at the end of this research, of three hypotheses of our own concerning the functioning of the (all) financial market from an evolutionary perspective:

1 *Adaptive Preference Hypothesis* (APH);
2 *Autopoietic Market Hypothesis* (APMH);
3 *Natural Price Hypothesis* (NPH).

The purpose of equational adaptive preference modelling

As we have shown in Chapter 2, the purpose of any model (whether logical or equational/quantitative) is to provide the technical/operational testing framework and modalities in the background theory of that model. In our case, the background theory is represented by the two previous chapters,[3] which incorporate the three (relevant) existing models of financial market functioning: *Efficient Market*

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Hypothesis – EMH (the most theoretically and formally/analytically elaborated); *Behavioural Market Hypothesis* – BMH (which has not yet succeeded in crystallising a theory of its own); and AMH (which is still in its infancy in terms of its theoretical basis, although, in our opinion, it already has the fundamental coordinates on which to build a theory and is, in this respect, ahead of BMH).

So, in a brief summary, the aim of equational modelling of adaptive preference in the financial market responds (must respond) to the following commands:

- formally/analytically 'capture' of the qualitative principles, hypotheses and conjectures presented and argued within the logic model of adaptive preference (see Chapter 2);
- provide mathematical relationships that allow for the development of fina - cial market predictions to test the proposed hypotheses/conjectures;
- allow further analytical developments until the formalization (to a sufficien degree) of the three hypotheses mentioned earlier (APH, APMH, NPH) which, in turn, acquire the predicate of testability in the Popper sense;
- allow the use (to be proposed in the research) of propensity probabilities or, at least, of propensity, even without a direct link with objective non-frequential probabilities,[4] a link which will be examined, however, in this research, from the point of view of possibility, that is, of the necessary formalism;
- have quantitative modelling valence that captures evolutionary aspects (adaptation, co-adaptation, co-evolution, mutation, selection, etc.), which will be taken into account later for the analytical development of the three hypotheses mentioned earlier.

Propensity theory

Since in this study we will propose a (causal) link between the concept of adaptive preference and that of propensity, we make a brief presentation of propensity and, related to it, the objective probability of the singular case (as we consider that it has happened in economics, where we do not have – in fact, it is not possible to have – repeatability of an event).

The concept of propensity

The (modern) concept of propensity (even if not the term as such, which is, of course, subsequent and relative to the concept) is already known from Aristotle, who built his physics (wrong, as Galileo further proved) based on the necessary tendency of entities (objects) to go to their natural places. Without explicitly establishing a link between trend and environment (or rather, the set of conditions in which a phenomenon occurs), Aristotle nevertheless captured the relationship between the type of entities in question and the type of movement trend, that is, he intuited a very interesting concept called today the (relative) propensity of entities (either objects or events). Subsequently, Toma d'Aquino[5] argued that human inclinations represent the substratum of human action[6] (Symboli, 2017).

Historically, in modern times, the concept of propensity has emerged as a result of the fact that in quantum theory, where we have what is called genuine indeterminism[7] (Johansson, 2009), we need an objective probability of the singular case.[8] As is well known, in the standard ('orthodox') conception, there is only one type of objective probability, namely, frequential probability.[9] This is, however, a probability of a repeatable case (i.e., on as long a sequence of repetitions as possible – ideally, an infinite sequence). The first systematic proposal of a theory of propensity belongs to Karl Popper[10] (1978) and can be described as follows:

- an entity (object, event, process) has an internal inclination, a disposition, a tendency to move from one state to another;[11]
- this tendency is a property of that entity, a property called propensity;[12]
- propensity is not an absolute property; it manifests itself, objectively, in the singular case, only in accordance with the conditions in which the event takes place;[13]
- the propensity thus considered is the (objective) probability of the singular case (event);
- the absolute propensity (which cannot be known as such but only through its manifestation as a disposition of the targeted entity)[14] is invariant precisely as a result of its 'declaration' as absolute. The problem here is that being invariant, even if we accept the derivation of the objective probability of the singular case from the relative propensity, we cannot return from probability to propensity.[15]

Let us examine some of the theoretical, ontological, and epistemological aspects of the concept of propensity (*Nota bene*: to facilitate the connection between propensity and probability, we give, in the Annex, a brief summary of the problem of probability).

POPPER'S (INITIAL) APPROACH

Compared to the basic elements, presented earlier, regarding Popper's conception of propensity as the basis of the objective probability of the singular case, we still remember the following:

- in essence, Popper finds propensity in objects (just like Aristotle), although he relativizes it to experimental conditions, not considering it an absolute necessity;
- the relevance of the probability shifts from being a property of the sequence of results obtained after the repetition (possibly infinite) of an experiment,[16] to being a property of the (unrepeatable) conditions of the singular case; the latter property is called *dispositional property*;
- propensity is, compared to probability, the qualitative or intensive or active factor;[17] more precisely, the propensity does not itself have a numerical value (which may verify or violate Kolmogorov's axiomatic framework) but is a

disposition to generate such a numerical value in the objective probability of the singular case (of course, this probability, once identified, will have to check the conditions of Kolmogorov);

- it seems that Popper, without accepting the repetition of the experiment (since he was referring to the singular case), did, however, make a connection with the frequential probability in the sense that, given the relative propensity, we must have no doubt that if we repeat the experiment, we would obtain a value of the frequential probability equal to that deduced from the examination of the relative propensity (i.e., of the absolute propensity 'guided' by the dispositional framework of the experiment);[18]
- propensity is a latent disposition[19] that is activated when the experiment is performed (*Nota bene*: obviously, no experiment, singular or not, can only take place in context, i.e., within given and known dispositional conditions);[20]
- propensity is a basis on which the objective probability of the singular case can be built (as we will show later, the objective character of probability refers exclusively to either the fact that we have frequential probabilities or – as Popper explains – we have the possibility, not necessarily updated, to obtain frequential probabilities);[21]
- in fact, Popper adopts two positions on his theory of propensity: (a) the initial position, in which he associates the propensity with the (potential) repeatability of the considered event; and (b) the subsequent/late position, in which he associates the propensity with the set of conditions (at the level of the universe, at the limit) in which that event occurs;
- Popper considers that, ultimately, speculative/metaphysical estimation of propensity is inevitable.[22] In this sense, it is curious that, initially, Popper believed that propensity could not be applied in the social sciences, although later it seems that he gave up this 'prohibition' (Runde, 1996).

CRITIQUE OF POPPER'S VISION AND OTHER APPROACHES (FROM THE SPECIALTY LITERATURE)

Popper's[23] proposal was received by the scientific community on all three 'tuning forks': critical, enthusiastic, and neutral. We will make a brief examination, next, only of the critical interpretations that have been presented, as well as the alternatives that various researchers in the field have proposed, in turn.

- *David Lewis (1980*) introduces the concept of *principal principle* to make a connection between belief[24] and chance. It should be mentioned that, by chance, Lewis means the objective probability of the singular case (i.e., what, as per Popper, received the name of propensity);[25]
- *Alan R. White* (1972) considers that propensity is a kind of *liability*, or *it does be*, which may suggest a property, either of an object or of a process (event) to contain, *in nuce*, a future event that can thus be predicted, based on the objective probability generated by this propensity;[26]

- *Ronald R. Gierre* (1973) appreciates that Popper's theory of propensity defines propensity as a tendency (of something) to produce results. However, we repeat that Popper never claimed to have an absolute propensity (independent of the set of conditions, i.e., the dispositional property of the experiment), which means that Gierre takes out of context Popper's alleged understanding of propensity. In essence, Gierre rejects the possibility (not the actuality) of producing a sequence that indicates (virtually) the passage of propensity into probability (Gierre, 1973);
- *D. H. Mellor (1975*), like Gierre, considers that Popper referred to an autonomous propensity in relation to the conditions of the experiment (this being also the position of this philosopher);
- *Charles S. Peirce* (1978) considers, long before Popper, Mellor, and Gierre, and in line with Aristotle's conception, that propensity lies in things and is autonomous from the set of conditions under which it could cause the objective probability of the singular case. However, Peirce did not refer to the singular case, as did Popper and, in his tradition, most of those who conducted research in this area. In his inventive and ingenious manner, Peirce[27] introduced for the concept that would later be called propensity, the term *habit*,[28] which he defined as a 'would be'.[29] By habit, Peirce means a predisposition of the human individual (culture, values, tradition, interests, etc.) that can generate a predictable behaviour but which is not to be confused with that behaviour (Popper will also use the term *would-be*[30]). This predisposition is obviously semantically equivalent to what is now called, in the specialty literature, propensity. We mention another important aspect of Peirce's position on propensity: he accepts only the efficien cause (in the Aristotelian sense) and rejects causation in the sense of Hume (constant conjunction of two events);
- *Joseph Agassi* (1964) considers that any law (natural – our emphasis) that expresses the necessity must be of a metaphysical nature (Agassi, 1964), because it concerns the deep foundations of reality.[31] As propensity concerns exactly fundamental properties, so necessary, it follows that this concept can only be metaphysical;
- *Richard von Mises*[32] (1981) considered propensity from the perspective of frequential probability, as it is established in a sequence of repeatable experiments (he calls this sequence as collective), as he doubted the existence of singular probability (more precisely, the objective probability of the singular case). Popper had rejected the use of the concept of collective with regard to the sequence of experiments – von Mises had developed this concept as early as 1928 – arguing that the discussion should focus on the conditions of the experimental arrangement, not on the concept of collective;[33]
- *Colin Howson* and *Peter Urbach* (2005) consider that probability can only be subjective,[34] although it can also be based on an objective probability, by which the two researchers call it, actually, propensity;[35]
- *Donald Gillies (2000*) agrees, in principle, with Howson and Urbach (2005) on the relationship between subjective probability and propensity. He also introduces the issue of the reference class. By reference class is meant the

totality of the experimental conditions[36] in which the singular event occurs.[37] On the basis of this concept, Gillies introduces the principle of the narrowest reference class as designating the way in which propensity can be identified [38] and from which, by certain deductive reasoning, he concludes that the probability of the singular case cannot be objective in any way.[39] Gillies proposes that propensity theories be of two types: (a) long-term propensity theories and (b) theories of short-term propensity. Long-term theories involve the repeatability of the event, in which case the resulting probability (as a frequency limit at the level of the whole sequence of experiments) being equal to the propensity. Short-term theories of propensity are appropriate for the propensity that generates an objective probability of the singular case. Gillies also tries to solve the dilemma of conditional probability – absolute probability through a terminological innovation: thus, he calls fundamentally conditional probability that probability which depends on a set of conditions (such as the set of conditions imagined by Popper or Fetzer – see later) and non-fundamentally conditional probability that probability which depends on a fixed event. Two conclusions can be drawn, conceptually, from this intervention by Gillies:

  - there are only conditional probabilities (some fundamentally conditional and others non-fundamentally conditional), so there are no absolute probabilities;[40]
  - there are no extended dispositional properties (possibly at the level of the entire universe, as Popper demands) but only reference classes of the experiment;

- *Brian Simboli* (2017) considers that the Peirce-ian habit is *necessitarian* rather than *possibilitarian*.[41] Of course, this excludes the relativization of propensity to experimental conditions, required by Popper.[42]

Main propensity issues

IDENTITY THESIS

In the question of propensity, the so-called identity thesis was stated and discussed. The identity thesis means the (logical) equivalence between propensity and probability. This thesis involves, of course, nuances and precautions, the most significant of which are the following:

- the identity thesis (I) is, actually, the conjunction of two identities:
  - interpretation of any probability (including conditional) as propensity (direction: from probability to propensity) – identity_1 (I_1);
  - interpreting any propensity as a conditional probability (direction: from propensity to probability) – identity_2 (I_2);
- so $I = (I_1) \wedge (I_2)$

Nota bene: however, this bi-directionality (at the limit, bi-univocity) implies non-invariance of propensity, a conclusion that raises further difficult discussions

- the propensive probability is closer, conceptually, to the probability as a ratio of favourable cases and (equally) possible cases;[43]
- the propensity of the singular case can be interpreted as a causal probability (Belnap, 2007).[44]

PROPENSITY – BETWEEN ONTOLOGY AND EPISTEMOLOGY

Regardless of whether the propensity is assigned to objects or events, a common problem in the two hypostases remains that of its foundation, that is, the ontological or gnoseological character of the propensity. As is well known, quantum field theorists claim that quantum probability[45] is a probability that belongs to quantum objects – in other words, regardless of the degree of knowledge of the behaviour of quantum objects, they are intrinsically subject to indeterminism (i.e., radical indeterminism). The term *intrinsic* obviously refers to the ontological attribute because the property of being indeterministic does not depend on the subject or the degree of knowledge of which it is capable. On the other hand, outside the quantum domain, it is presumed that we do not have indeterminism but that, due to incomplete knowledge of reality, we are forced to model stochastic phenomena, therefore, to associate probabilities with events. It is obvious that, in the latter case, we are talking about an epistemological (more generally, gnoseological) nature of probability. These considerations can be transferred, without introducing 'impurities', from probability to propensity. There are also opinions according to which the propensity is of ontological type (Johansson, 2009) and opinions according to which the propensity is of epistemological type (Popper, 1959). It should be noted that objective probabilities, that is, frequential probabilities, do not make the transition from epistemological to ontological by the mere fact that they are objective.[46]

In all approaches that accept the concept of propensity, it is implicitly accepted that probability is a measure of possibility. It is clear that this assertion is applicable to propensity theory (Suárez, 2014) rather than frequential probability theory, and in fact, it could be reformulated as follows: probability is a measure of propensity – an aspect that emerges, explicitly or implicitly, from almost all researchers' positions who leaned on the concept of propensity.

PROPENSITY AND CAUSALITY

Undoubtedly this problem – the ontological nature versus the epistemological nature of propensity – is one derived from a more primitive problem, namely, that of the relationship between causality and propensity. Here are some considerations in this regard:

- there is no change without causality. This 'postulate' is, of course, an inductively established one,[47] but it seems to ensure maximum intelligibility in the process of knowing the world (both objective and subjective);

- based on the previous 'postulate', regardless of whether we are in a deterministic or an indeterministic world, the effects are always generated by causes;[48]
- the problem of the anteriority of the cause to the effect is controversial: we can accept, as a general rule, the anteriority of the efficien cause (in the Aristotelian typology) to the effect, but in the cultural field (economic, social, political, etc.), there is a cause that is subsequent to the effect – final cause (or purpose);
- regardless of the type of cause we are talking about, causality is 'behind' any change;
- accepting the principle of causality and taking into account the fact that propensity is considered to generate the (objective) probability of the singular case, it results that propensity can be considered a cause of this probability;[49]
- the (Popperian) theory of propensity represents a general and indeterministic theory of causality;
- in the field of propensit , the *axiom of dominance* is functioning:
    - it is a principle of connection between a basic order of preferences and an induced order regarding the order of possible strategies;
    - the principle of deterministic rational choice: strategy 1 is preferred to strategy 2 if the causal consequence of strategy 1 is preferable to the causal consequence of strategy 2;
    - the axiom of dominance extends this principle to the stochastic (probabilistic) case;[50]
    - without the axiom of dominance, the theory of propensity is empty;
    - the axiom of dominance connects the theory of propensity to practical problems and to praxiological problems;
- the relationship between propensity and causality is particularly illustrated by the *Humphreys paradox* (Humphreys, 1985) (which we will not discuss here in detail),[51] which argues, in essence, that while causality is not symmetrical in time (e.g., by reversing the algebraic sign of the temporal variable), the probability/propensity, on the other hand, manifests such an asymmetry: thus, if P(A|B) is defined, then P(B|A) is also defined [52] Consequently, propensity cannot be a generalization of the cause.[53] *Nota bene*: correlation is a probabilistic concept, but causality is not such a concept;[54]
- there is also the opinion that propensity should be applied (or taken into account) only in cases of radical indeterminism (i.e., that indeterminism that is not the result of lack or incompleteness of knowledge) (Johansson, 2009). In this context, the application (or applicability) of propensity to the economic field requires special propaedeutics, which must be developed with sufficien discernment, so that either it is shown that in the social field (i.e., where we have free will), there is radical indeterminism, or it is argued, convincingly, that although we do not have radical indeterminism, we do have a cognitive indeterminism that still justifies the use of propensity. Here we can raise an interesting issue, due to interpretation of Niels Bohr on indeterminism (Johansson, 2009): in essence, Bohr argues that indeterminism (the radical) is a necessary effect of quanticity. If we extend the concept of quanticity

(*Nota bene*: it is, of course, to examine the 'legality' of this extension) to the *concept of discretity*, that is, of a discrete, ontological nature of the economic phenomenon/event, then we could consider that in economy/society, we have radical indeterminism (or possibly quasi-radical), and therefore, the introduction and use of propensity are justified [55]

TESTABILITY (AND TESTING) OF PROPENSITY

Like the problem of nature, or numerical value, the problem of the testability of propensity is not elucidated at the level of the scientific community. The concept of propensity has been (and is) treated especially in a logical key, not in a mathematical one. One of the reasons for the almost exclusively logical approach (i.e., from an exclusively qualitative perspective) of propensity is that this concept is somehow mysterious, with a rather obvious metaphysical nuance.[56] Of course, labelling the concept of propensity as metaphysical concludes the discussion – no metaphysical concept is testable empirically.[57] Giving up the metaphysical nature of propensity,[58] the problem of testability, and of propensity testing, must be examined in a similar way as the examination of any positivist concept. Our position in this matter is as follows.

Given the propensity is credited (to use a preferred expression by David Lewis, namely, *credence*) as generating or standing (causally) on the basis of the objective probability of the singular case, propensity can be seen as a prediction or as a predictive statement[59] that would somehow be tested by examining the probability actually realized (i.e., updated) following that singular experiment. It should be noted that, even assuming that this would be possible, it would go beyond the rigorous framework of Popper's testability, because, if the 'prediction' were refuted, we could not say that the propensity is false. This is for at least three reasons:

- propensity is an intrinsic property of the entity in question (object, event, etc.); it is not susceptible to be factually refuted;
- the problem of inverse probability (discussed earlier) returns here, which also does not allow the change of propensity;[60]
- there is no procedure, developed by the specialty literature, to show how the 'refuted' propensity should be modified (similarly if the refutation concerns a hypothesis or conjecture type statement) so that it is still capable of generating new statements about the objective probability of the singular case.

There are two arguments in the literature that seem to prevent the generation of the objective probability of the singular case from propensity:

- Humphreys's argument (1985): propensity does not verify the axioms of Kolmogorov's theory of probabilities. This argument results from the fact that

probability theory implies the Bayes theorem, which is invertible (but the propensity is not invertible):

$$P\left(B|A\right)=\frac{P(A\mid B)\cdot P\left(B\right)}{P(A\mid B)\cdot P\left(B\right)+P(A\mid \bar{B})\cdot P\left(\bar{B}\right)}$$

- in order for the propensity to be a probability, there must also be conditional propensities so that the conditional probabilities can be 'extracted'.[61] However, according to both Popper's late proposal (global conditionalities) and Fetzer's position (general local conditionalities), propensity is not 'conditioned' by an event but by a field of conditionalities that exceeds a fixed event.[62]

In view of the just-mentioned difficultie regarding the consideration of propensity as representing a predictive statement, we consider that another possibility of testability (or testing) of propensity could be the following:

- it is obvious that the singular event cannot be falsified because it does not allow predictions. In this context, a 'solution' could be to falsify the objective probability generated by propensity, but this can only be done through counter-factual analysis;
- a suggestion can be used (Belnap, 2007), based on the concept of *putative propensity* (supposed/presumed) which could be used for factual testability (which, however, requires a preliminary theoretical construction, as it must be justified that the propensity is not invariant, which raises, as we have shown earlier, the problem of inverse probability);
- another suggestion for testability may come from the concept of causal probability, mentioned earlier (Belnap, 2007), in the sense that propensity is considered a cause of causation (lat. *causae causante*).

TYPOLOGY OF PROPENSITY THEORIES

The specialty literature does not deal extensively with this problem of the existence of a typology of propensity theories. In fact, the only scientific interest of a possible such typology would lie in the association or non-association of propensity with the frequential aspect of the resulting probability. Recall that Popper (in the initial version of his proposal) accepted a (virtual) connection of propensity with a sequence of repeating the experiment, a version which he later gave up (replacing the 'call' to this sequence with the overall conditions in which the singular case is made kept in sight). The one who insisted on a typology of propensity theories is Donald Gillies. He proposes two classes of theories of propensity (Gillies, 2000):

a. theories of *long-term* propensity: those theories that are 'verifiable' by performing a long sequence of replications of the experiment;[63]

b. *short-term* propensity theories: those theories that accept the singular case. Regarding the propensity of the singular case, there are two positions in the specialty literature:

   - the set of conditions in which the singular event takes place is a set that refers to the entire universe (Popper's late position);
   - the set of conditions in which the singular event takes place is a set that refers to the local context (space-time), having no global significance. (Fetzer, 1981)

It is obvious that this typology (as, by the way, any other typology one could imagine) deviates principally from Popper's intention to substantiate an objective probability of the singular case. For this reason, we will not further examine the question here.

OTHER ASPECTS OF PROPENSITY

- the singular experiment expresses uniqueness, not only singularity;
- propensity influences future events without determining them (because, as mentioned earlier, propensity can be considered as a cause that causes a cause);
- propensities create a situation of asymmetry in time: example - I want to win the Nobel Prize; prize in year 'i', I win it in year 'i + 1', so I don't want (I don't have the propensity) to win it in 'i'. This is a very important aspect from the perspective of economic modelling, as it allows for non-invariance of propensity;
- propensities involve degrees[64] – in fact, this is why they can be associated with probabilities;
- Bayesian theorem fails in the case of propensities, an obvious conclusion since this theorem operates with *subjective* probabilities of the singular case;
- the relevance of propensity is causal, while the relevance of objective frequential probability is statistical (i.e., it is 'causal' only with reference to the mean, but the mean does not exist ontologically; it is an epistemological construct);
- the propensity is a vector (it is directional), while the probability is a scalar (a real number). This is the reason for which most researchers believe that probability is reversible over time but not propensity;
- logically, no event is current – both past and future events are only possible, and the propensity indicates the *causal* degree of this possibility, while the probability indicates the *statistical* degree of this possibility.[65]

Assumptions of the equational model of adaptive preference

As mentioned earlier, the general logical basis of the equational model of adaptive preference is that examined in Chapter 2. In this section we will summarize the most important coordinates of this logical basis, namely, those that are likely to contribute to the quantitative (equational) aspects that we intend to develop in this

study. Specifica ly, we will perform this synthesis in the form of the assumptions we propose to consider. There are three categories of assumptions – theoretical, methodological, and instrumental – with an increasing degree of dependence, in this order, on the immediately preceding category, so they must be developed/designed exactly in this order. From an epistemological point of view, theoretical assumptions are in most cases sufficient in sufficien cases, the formulation of methodological assumptions is required, and in the least cases, instrumental assumptions also appear. It is obvious that the theoretical assumptions have the most degrees of freedom, followed by the methodological assumptions, followed, in their turn, by the instrumental assumptions. We will develop, in the following, the theoretical and methodological assumptions.

Theoretical assumptions

Theoretical assumptions are those assumptions that have the primitive justifying role (in other words, the founding role) of the construction we intend to build in the matter of quantitative modelling of the functioning of adaptive preference. At the limit (but, obviously, this is not the case for this study, which has more modest claims) theoretical assumptions are axioms or principles, that is, 'decrees' of the researcher, which in turn do not require more primitive justification. Theoretical assumptions are therefore discretionary and, in fact, have a character, often arbitrary, strongly dependent on the personality, background, and imagination of the researcher in question. In general, theoretical assumptions (when not unique) are ordered from the perspective of their importance/relevance to the issue/area/field of interest in question. If such an order is operationalized, it cannot have (for obvious reasons) a criterion for the order in question, so the order can only be lexicographical.[66] In this context, for the present study, we propose the following theoretical assumptions:

- (*TA*1) the financial market is characterized by *behavioural efficiency*, not informational efficien . At the limit, this assumption can be transformed into a hypothesis (according to the Fama or Lo[67] model), namely, the *Behaviourally Efficient Market Hypothesis* (BEMH);
- (*TA*2) the economic agent is *the genome*, the trading strategy is *the individual*, the financial market is *the species*, and the normative framework[68] is *the environment*;
- (*TA*3) the trading strategy is selected (by adapting the individual transaction), the financial market *evolves*, and the financial market-environment pair *co-evolves*.

Methodological assumptions

Methodological assumptions are not primitive assumptions, in the sense of theoretical assumptions, but operational assumptions, that is, assumptions that allow the use of ways (logical, mathematical, or empirical) to examine the intended object of knowledge.

Methodological assumptions are not autonomous, as in the case of theoretical assumptions, although they (still) retain the imprint of the researcher's possibilities in the field of interest but are logically dependent on theoretical assumptions (manifest, in established terminology, a *path dependence* – not historically, as is usually the case, but logically, i.e., we have a *logical path dependence*). In this context, for the present study, we propose the following methodological assumptions:

- (*MA*1) the functioning of the financial market is accessible *to methodological holism*, not methodological individualism;
- (*MA*2) adaptive preference is assimilated to *relative propensity* (here in the sense of Fetzer, not Popper);[69]
- (*MA*3) the propensity represented by preference (we will call this propensity with the term *proference*[70]) is the cause of assigning (subjective) probabilities in choosing the trading strategy;
- (*MA*4) the allocation of probabilities, generated by the proference, is of Bayesian type, and their *a priori* distribution is made, in conditions of uncertainty, based on the principle of insufficient reason of Laplac [71]

From an instrumental point of view, in order to find the (numerical) solutions to the differential equations or to the partial differential equations involved, discrete modelling can also be used (as far as possible), so the *Finite Difference Method* (FDM) will be used.[72]

Analysis of assumptions

Analysis of theoretical assumptions

(***TA*1**): the financial market is characterized by *behavioural efficiency*, not informational efficien .

The issue of the relationship between information and behaviour was discussed, quite analytically, in Chapter 2 (section "Information and behaviour"). As is well known, EMH is based on the theoretical assumption of information as the main (more precisely, the only) variable that matters in the dynamics of the price (or, equivalently, of the yield) of a financial security – moreover, EMH refers, as mentioned earlier, to the *informational* efficienc of the (financial) market. Our study will try to show that, in fact, it is not information that influences price[73] but behaviour. This idea, in one form or another, is contained in numerous position papers in the specialty literature (Farmer & Lo, 1999) and can be resumed as follows:

- price is always the effect of the relative variation of supply and demand for an economic good (product, service, financial security). Therefore, even supposing that an economic agent receives an information on the financial

market (e.g., a company's announcement of its profit forecast, i.e., its dividend forecast)[74], if he/she does not act on the market by selling/buying fina - cial securities in the category affected by that information, the price does not incorporate the information;

- it is therefore obvious that the integration of the information into the price depends on the behaviour generated by that information. But, obviously, the information in question may not generate any behaviour – for example, the agent in question has a 'reverse' preference to a trading strategy that would be suggested by that information and, in this case, although aware of the information, decides not to trade accordingly.

This assumption ('axiom') is extremely important for the approach involved in this research, as it represents a departure from the assumption considered by EMH (information), on the one hand, and even from the (implicit) assumption considered by AMH (adaptation), on the other hand.[75]

At this point in the discussion, the following problem arises: if an information accessible (no matter its nature – public or private) to agents operating in the financial market does not lead, for reasons that for the time being can be ignored, to a commercial (market) act, for example, to the assumption of a transaction within a given trading strategy or within another trading strategy, the question arises whether that information not used, that is, not objectified in behaviour, remains 'harmless' or has an effect, and if it has an effect, what is that effect and what is the target on which that effect is exerted. We discuss this issue next:

- case 1: our view is that an information that remains unused from the perspective of an act of commerce is not entirely passive. It can be presumed that the information, more precisely, the meaning of that information, is below the threshold of meaning that makes the agent integrate the information into a behaviour (or, more generally, into the variation of a behaviour);
- case 2: the information, although received and above the threshold of significance, is misunderstood in terms of its meaning. Here is the 'origin' of both the noise, of which Fama speaks (i.e., of unsophisticated or irrational agents generating opportunities for sophisticated/rational agents), and the fertile error (Soros, 2009);
- case 3: in both cases mentioned – meaning below the significance threshold and misunderstood meaning – we consider that there is a latent effect, which accrues to the agent's account. But where does this accumulation occur? Our view is that information not objectified in acts of commerce, that is, not objectified in behaviours, accumulates, in the form of a shifting tension[76] in the account of preference.[77] The way (direction and 'quantity') in which preference varies is obviously a crucial issue in the logical and quantitative model of adaptive preference and will be discussed in due course.

The concept of behavioural financial market efficienc is a new concept (at least in terminology), although suggestions of such efficienc are found, unfortunately

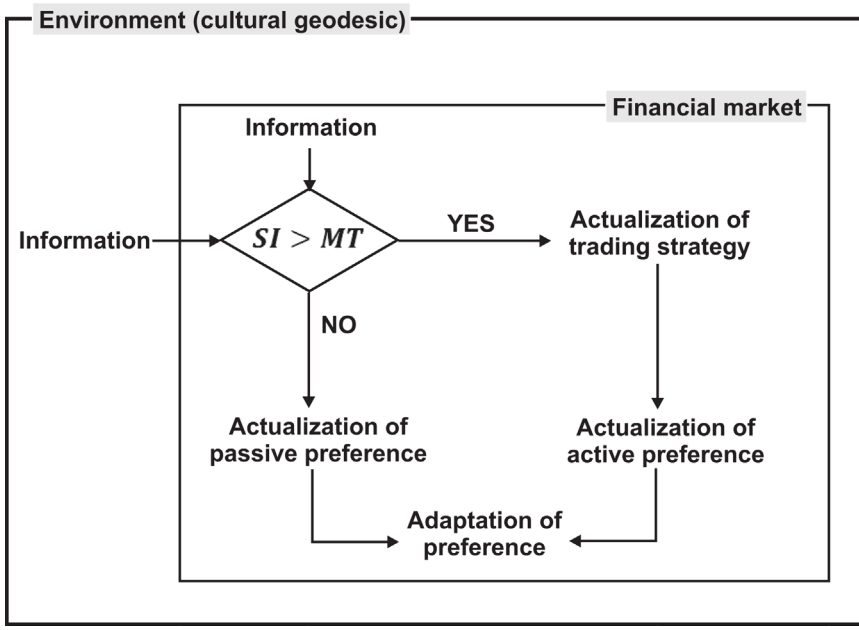

Figure 3.1 General scheme of functioning of the assumption *TA*1.

Source: Authors.

in an unsystematic and incomplete way, both in general economic modelling – see the concept of *routine* (Nelson & Winter, 1985) – and in financial market modelling (or attempts to model) of the financial market – for example, Lo (2019) argues that the financial market[78] selects the trading strategy (so it does not select the physical individual or the formal organization as such) based on the proven effectiveness (or possibly efficien [79]) of obtaining returns in the fina - cial market.

Essentially, behavioural efficienc does not differ from informational efficienc in terms of the mechanism for ensuring market efficienc (the difference is only the introduction of an additional praxeological link between information and its active or actual/effective use). Such a mechanism could be depicted as in Figure 3.1 (where *SI* denotes *significant information*,[80] *ST* denotes *significance threshold*, *MT* denotes *meaning threshold*, and *actualization* means the three components: operating a new strategy, abandoning an existing strategy, and modifying an existing/ongoing strategy).

So, in our view, preference (more precisely, proference) adapts not only as a result of the operation of information through behaviour but also through its non-operation (so-called harmless information or, if you like, white information[81]). This non-manifest impact of information is difficul to express equationally, but it

is as important, in our view, as the manifest impact, that is, operated through the updating of the trading strategy.

(***TA2***): the economic agent is *the genome*, the trading strategy is *the individual*, the financi l market is *the species*, and the regulatory framework is *the environment*.

The AMH is a proposal for financial market modelling – even with pretensions of a financial market paradigm – that claims to be based on the evolutionary perspective, present in general economic theory, though much less so in financial market matters. This referential claim implies, of course, a conceptual family appropriate to the evolutionary model. It must be said that the AMH does not present a coherent set (and, in our view, not even a complete set) of such concepts designed to provide a convincing theory of the adaptive (financial) market. Since the objective of this study is to design a theory (or theoretical elements) of adaptive preference, the need to propose such a set of concepts is obvious. Adaptation, as shown in the previous parts of this book, is a 'moment' of evolution (more precisely, of co-evolution); therefore, this assumption requires the specification of the whole (co-)evolutionary phenomenology of the financial market from the perspective of adaptive preference. The clarification will be made furthe .

We have pointed out elsewhere that, along with Lo, we also consider the individual[82] that acts in the financial market is the trading strategy. This means that the 'natural' selection operating on the financial market will be exercised on the trading strategy (*Nota bene*: hereafter referred to as *TS*). In other words, *TS* is the phenotype that will be either accepted by the environment or rejected (either totally or partially). But here a problem arises that needs to be clarified: the *TS* is a generator of *individual transactions* (*Nota bene*: hereafter referred to as *IT*), that is, within the framework provided by the *TS*, several commercial acts are operationalized – in fact, all commercial acts decided by the human *economic agent* (*Nota bene*: hereafter referred to as *EA*) on the given *TS* 'line' are operationalized (e.g., within the *TS* characterized by aversion to ambiguity). The question that arises is: why would the environment not select *IT*? Why should it select *TS*? Our answer to this question is the following:

- first, a useful analogy: in biological evolution things happen in the same way: the environment of the biological phenotype does not select (by acceptance or rejection, as the case may be) the phenotype once it exists but once it manifests itself in acts framed by biological phenomenology. For example, a specimen of a predatory animal, born without a leg, is selected (in the sense of rejection) by the environment only if the animal in question tries to feed itself by catching a prey – because of the congenital disability, it will not be able to catch the prey, so it will starve and so it will not be able to reproduce to pass on the disability in question. If, however, it is a social animal, living in a pack, and the pack 'decides' to feed it on the prey caught by individuals

without the disability, it will be able to reproduce. So, selection is only in the (biological, in the hypothetical case described) interaction and not in itself;[83]

- in the financial field, *IT* is how the *TS* interacts with the environment that will make the selection. *IT* is, by analogy, the attempt to 'catch' a prey – in this case, to get a net gain from the financial market. The environment 'learns' about the *TS* exclusively through the *IT* assigned to that *TS* , and not directly.

Thus, the *TS* is the individual, and the *IT* is the act of manifestation of the individual, the 'litmus paper' on the basis of which the *TS* is assessed, graded, and either rewarded or penalized by the environment.

The individual is part of a species: we propose that the species in this case to be the financial market itself. The financial market can therefore be defined, in this perspective, as the whole of the *TS* , which is not far from the 'textbook' defin - tion, which defines the financial market as the totality of acts of trade in financial securities in a given economic space. We return to the differ nce between our position and Lo's (2019) position – the latter sees the financial market as the environment in which financial transaction occurs and which, as an environment, selects *TS* (also recognized by Lo as representing the individual). It is obvious that this 'equation' is missing the species: it jumps from the individual (which, as a phenotype, is selected, develops, adapts, etc.) directly to the environment, without the individuals forming a (co-)evolving species.

We consider that the species is precisely the financial market (*Nota bene*: hereafter referred to as *FM*). It is the *FM* that evolves – in fact co-evolves in tandem with the environment.

As for the environment (*Nota bene*: hereafter referred to as *M*) in which the species operates, that is, the *FM* , we consider that it must be represented by the cultural geodesic of the economic/social system in question. The concept of *cultural geodesic* (*Nota bene*: hereafter referred to as *CG*) has the following meanings, in our view:

- contains, as a basic component element, the formal regulatory framework of the economic system (obviously, particularly that is specified for the financial field but also the general regulatory framework, including, as a primary regulatory grid, the social contract embodied in the Constitution);
- alongside the formal normative framework (e.g., the prohibition of trading in financial securities which have drugs as their economic support), *CG* also includes the informal normative framework – moral norms, customs, local/temporal habits, and so forth – that is, what (as we have pointed out) Peirce (1978) calls *habit* and Bourdieu (1991) calls *habitus*;
- thus, *CG* is, from a behavioural point of view, a complex system of formal and informal constraints/incentives, characterizing, from a general cultural point of view, the economic system in question. *CG* acts as an attractor for the design of the *TS* and for the current conduct of *IT* . In this sense, *CG* has an important impact on the genome (which we will discuss later), hence

on propensity (more precisely, on proference), constituting a sui generis predictor for the behaviour of the EA in the choice and instrumentation of the TS, that is, of IT, be it a rational/sophisticated or an irrational/unsophisticated EA.

The concept of EA must also be clarified within this assumption. EA is, from a phenomenological point of view, the vehicle through which the inter-action between IT and M (ultimately, as mentioned earlier, between TS and M) takes place. However, EA appears as an additional 'ingredient' in the (co-)evolutionary mechanism that the study will ultimately propose. The following considerations attempt to clarify this assertion:

- EA does not interact with M *per se* but via TS (and even more directly, via IT). So, from a logical point of view, EA is not 'necessary' in the (co-) evolutionary model we are considering;[84]
- however, EA is the location of preference/proference, that is, the location of the TS genome, which is of course present in any IT. Thus, EA is necessarily in the (co-)evolutionary mechanism that we will assume in the research, as that component that generates the mutations to be inoculated into TS, that is, into the phenotype that will interact with M to obtain a 'verdict' – of acceptance and of rejection.

A final issue in discussing this assumption is that of representative EA. Indeed, the physical individual who holds the proference on the basis of which financial market interactions occur (as TS and as IT) can be either a biological physical individual, that is, a singular individual, or an organizational individual. Under today's sophisticated capitalism,[85] single individuals are almost non-existent,[86] which is why we will speak, in what follows, of organizational individuals, and EA will be understood everywhere as organizational.

The synoptic expression of this assumption is shown in Figure 3.2.

(***TA3***): the trading strategy is *selected* (by adaptation of the individual transaction), the financial market *evolves*, and the financial market-environment pair *co-evolves*.

This assumption is correlated with assumption $TA1$, although of course the two assumptions are not redundant to each other. Thus, while assumption $TA1$ establishes positions (or identities or, still, structural aspects), assumption $TA2$ establishes roles, that is, functional aspects. It is important to note, with all emphasis, that the phenotype is TS. This means that the 'selector' (identified by us with the normative framework or, more broadly, the *habit/habitus*) will accept (or reject, as the case may be) not IT but the group of the IT homogeneous or similar that conceptually forms ST. Obviously, with the selection of the TS, the cohort of the IT specific to that TS will also be selected by default. As mentioned earlier, IT should not be confused with TS, although both entities appear to be of an

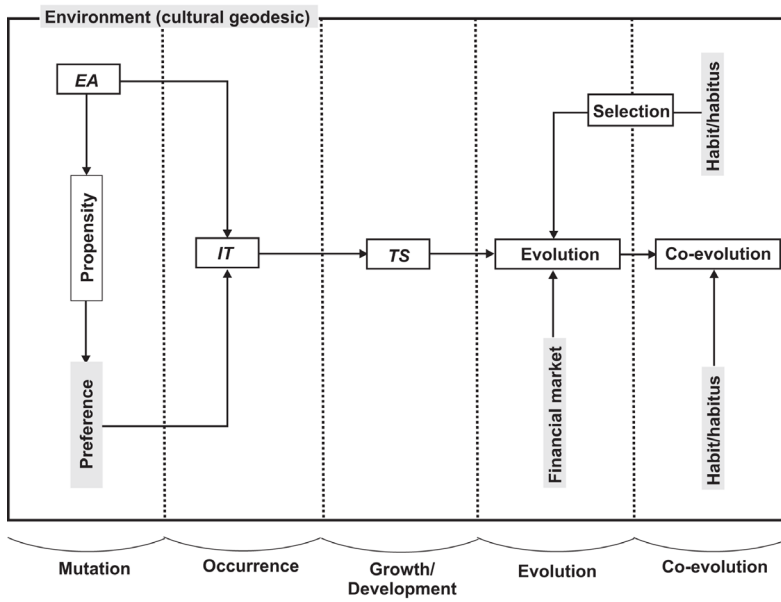

Figure 3.2 General scheme of functioning of the assumption *TA*2.

Source: Authors.

individual nature. To further clarify this theoretical distinction, we appeal to the well-known concept of a stochastic experiment:

- suppose we want to perform an experiment on a phenomenon F;
- performing an episode of this experiment is an occurrence of F;
- the totality of the hypostases (either possible or actualized), that is, the distribution of events occasioned by the experiment, describes, in a complete way, the phenomenon F;[87]
- in the same way, the totality of IT completely describes TS.

The adaptation process (to the environment) is located at the IT level. In other words, a certain de-tensioning of the relationship between the TS and the environment is achieved at the level of each IT – these are small adjustments, of a functional, not structural, nature – so that the sum of these micro-adjustments of an adaptive type eventually (after the accumulation of a sufficien number of micro-adjustments) enshrines either the acceptance or the rejection of the TS. A biological equivalent, for a clearer understanding of this issue, is as follows:

- an animal (individual/phenotype) manifests itself, under various circumstances, in its attempt to survive, by small adjustments in its current behaviour

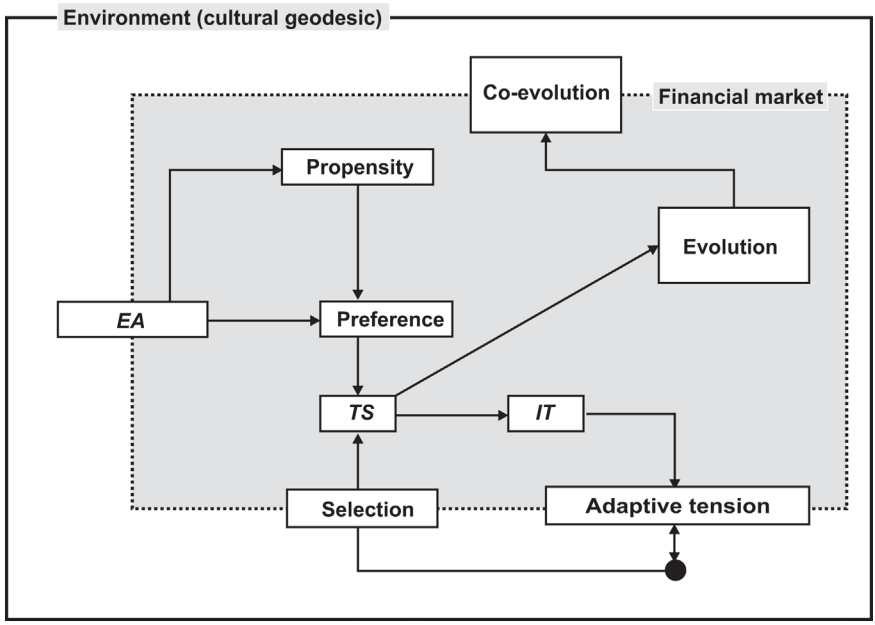

Figure 3.3 General scheme of functioning of the assumption *TA*3.

Source: Authors.

in relation to the pressures (either constraints or opportunities) of the environment – for example, not being a climber, it occasionally climbs trees after prey (or, equivalently, climbs prey in trees to ward off rivals – of the same or other predator species);

- according to Darwinism,[88] these small adjustments will not count in their genetic transmission – the offspring of that animal will not have the genetic ability to climb trees, although, occasionally, they will be able to imitate this behaviour, not at the genetic level but at the memetic level.

As shown in Figure 3.2, the individual, that is, the *TS* , is the growing (or developing)[89] entity, and the financial market is the evolving entit .[90]

As for co-evolution, it 'requires' two species, not one species and a selector environment. Therefore, conceptually, to discuss co-evolution in the financial market, we will have to consider the environment (the regulatory framework or *habit* or *habitus*) as species, with which the financial market interacts. Outside this assumption, we cannot talk about co-evolution. As our commitment in this research is to elaborate a co-evolutionary model of adaptive preference, at the appropriate time, we will provide all necessary clarifications. Figure 3.3 graphically illustrates the operation of this assumption.

(***MA***1): financial market functioning is accessible to *methodological holism*, not methodological individualism. *Nota bene*: from a pathway dependence perspective, $MA1$ is associated with $TA1$.

In relation to this first methodological assumption, it must be said that it signifies a dissociation 'without rest' from neoclassical economic theory, on which, as has been shown in previous studies, the EMH is built. Indeed, in the case of the EMH (as in that of Samuelson's martingale), the fundamental approach was that of methodological individualism – that is, it was presumed that the individual (whether physical or organizational) is the basis of decision and consequent behaviour, or, in other words, the macroeconomic has its cause in the microeconomic. This is the reason why, in EMH (and in the 'rescue' variants of this assumption in the face of empirical anomalies), the preferences of the individual are considered exogenous, given, and invariant variables. In our view, the correct (and realistic) approach to the functioning of the financial market (as to the functioning of any economic market, for that matter) is that of methodological holism. Methodological holism can be described as follows.

The parts and the whole influence each other, in an endless circular causality, in which, however, the first act is from the whole to the part, not from the part to the whole. In our case, the parts are TS, and the whole is FM. Circular causality is embodied in (manifested by) reciprocal (fetality)[91] norms of reaction. The parts can only be understood through the whole once the whole has come into existence. More analytically, we can say the following: the whole (FM) does not exist before the first IT takes place, which means that the whole is generated by the parts, but once the first IT has been objectified, the whole thus formed (FM) will act as a cause-master (as we will show in more detail later, as a cultural geodesic) on the other IT, starting with the second.[92] It is no longer an 'individual' person who acts but organizations, that is, organizational individuals (e.g., investment funds, venture funds, mutual funds). In connection with this feature of the financial market, we add the following analytical considerations:

- organizational individuals are in turn made up of 'individual' people – this is true in the social domain of every organization, from the most insignificant to the state (as an organization). This means that, more or less, a certain predominance of an 'individual' person (of an individual personality) occurs within the organization, but ultimately, even in this situation, an organizational culture or organizational ideology is formed which defines the organization as a methodologically individual, as will be considered later;
- so, against the background of organizational culture/ideology, operational decision-making (and, of course, implementation/enforcement) is carried out by an 'individual' person (physical individual). This does not, however, lead to the idea that the physical individual is equivalent to the organizational

individual – the physical individual, even if it is the one who has imposed his or her point of view on the positioning of the organization, subsequently acts as an agent for the organizational individual;
- this delimitation (necessary and useful, we believe) between the physical individual (integrated into the organization) and the organizational individual – the latter as an aggregate entity of physical individuals united by a common belief/preference – will be useful precisely in terms of forming and operationalizing the concept of proference (propensity manifested in preference).

As we have mentioned elsewhere, the concept of the organizational individual does not overlap with that of the representative agent (or average agent) in neoclassical theory, that is, the theory based on methodological individualism. The differences between the organizational agent (*OA*) and the representative agent (*RA*) can be summarized as follows:

- *RA* includes all physical individuals who manifest themselves as economic agents in an economic space, while *OA* integrates (aggregates) only those physical individuals who share a particular belief/preference in financial transactions. One might object to this distinction that, even in the case of methodological individualism, *RA* is also constructed on the basis of a community of preferences (or values, interests, etc.). Our response to this presumptive objection is as follows:
- *RA* is not an operational agent in the market but only an abstraction for making logical and possibly quantitative models (the operational agent being still the physical individual abstracted in *RA*), whereas *OA* is effectively an operational agent, in the sense that the trading decision is made by the *OA* itself, not by the physical individual who is contained in that *OA*;
- once the *RA* 'list' is established, no further *RA*s can be built, for example, of order 2 (by aggregating *RA*s of order 1), whereas in the case of *OA*s, there is still 'room' for building organizational representative agents (*ORA*s): for example, *ORA*s for mutual funds can be built by aggregating all *OA*s acting within mutual funds. It follows that, in the context of *OA*s, there is simply one more (possible, if modelling reasons require it) level of aggregation, namely, the *ORA* level.

Of course, the fundamental aspect of *methodological holism* lies in the concept of *cultural geodesic*. We present some of the meanings to be associated with this concept (in addition to those mentioned earlier in relation to this concept):

- *a first* meaning of cultural geodesic is that of collective propensity (at the level of society[93]). Collective propensity refers to a general cultural basis, including normative framework, historical tradition, dominant religion, geopolitical influence, and so forth, which induce a general inclination regarding the behaviour of individuals (either physical or organizational) in that society.

The state, as the representative institution of the society and the bearer of the 'administration' of the sovereignty of the corresponding people, follows, of course, the lines of behaviour contained in that propensity: for example, a cultural geodesic of a militarist-expansionist type will 'colour' the behaviour of that society in a specific way;

- *a second* meaning of cultural geodesic is that of collective preference. As we have previously opined, preference is an objectification of propensity (which led to the proposal of the concept of proference), so cultural geodesic is a collective matrix of initiation, design, and implementation of behaviours of all kinds within society;
- *a third* meaning of cultural geodesic is that of a *behavioural attractor*. By behavioural attractor is meant an institutional 'device' that induces in any specific behaviour a general component contained precisely in that cultural geodesic. In other words, specific behaviours will contain a class or category component that unifies them from a general, common perspective. For example, in a society where the cultural geodesic is collectivist (as was, until recently, the case in Japanese society), specific, individual behaviours will contain this mark of collectivism, a mark that carries behavioural aspects such as empathy, solidarity, self-sacrifice for the collective (from the family to the state), and so forth;
- from the perspective of logical and quantitative modelling of the functioning of the financial market (including adaptive preference), cultural geodesics have an importance that cannot be overestimated, constituting, in our opinion, a kind of framework propensity, or master propensity, or background propensity, or guiding propensity, which guides, more or less strongly, individual propensities in the society in question.

A graphical image of how this methodological assumption works is given in Figure 3.4.

($MA2$): adaptive preference is assimilated to *relative propensity. Nota bene*: from a pathway dependence perspective, $MA2$ is associated with $TA1$ and $TA2$.

With this methodological assumption, we link adaptive preference and relative propensity. We have previously shown that we cannot conceive of an absolute propensity[94] and that we must adopt the concept of relative propensity. Relative propensity is a propensity with an objective character but which is revealed as such (i.e., it is observable[95]) only by objectifying it within a set of given conditions (as already stated, we will adopt here Fetzer's position on the local, and not global, character, as Popper demands, of the set of such conditions of propensity hypostatization).

In this conceptual framework, the assimilation of adaptive preference to relative propensity can be made on the basis of the following requirements or justifications.

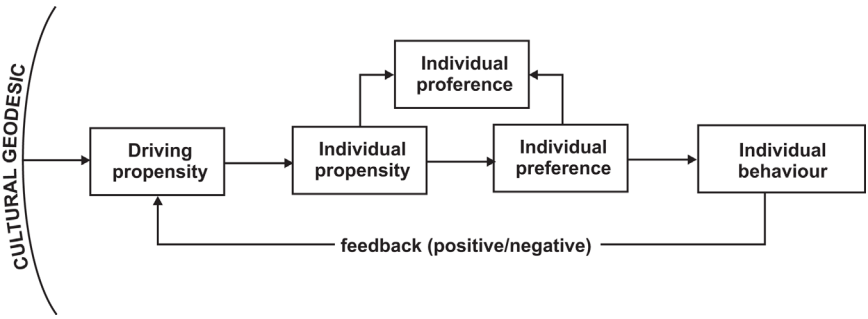

Figure 3.4 General scheme of functioning of the assumption *MA*1.

Source: Authors.

Propensity does not act in itself but through preference. In this sense, it can be said that the observable propensity is preference itself. Since preference has a subjective character,[96] it follows that we could adopt the position (referred to earlier) that propensity-type probability does not retain the objective character of propensity but, although it is based on (and originates in) the objectivity of propensity, is subjective in nature (*Nota bene*: more details about this logical and, probably also, psychological connection will be given later when we discuss *MA*3 and *MA*4).

Therefore, the content of the *MA*2 assumption (adaptive preference is assimilated to relative propensity) must at least be understood:

- the relative stability of preference[97] is explained precisely by its 'anchoring' to propensity. As a result of its objective character, propensity has a certain immunity to pressures for change from the margin of the behaviour of the individual concerned. In the now-established jargon, propensity is resilient and robust to perturbations (of course, within limits that are accessible, though not controllable,[98] by the subject involved);
- there is a circular causality between propensity and preference – more pronounced, however, from propensity to preference than the other way around. This is the reason for the above construction of the concept (and term) of proference, since the two properties are engaged in a kind of sui generis co-evolution. So, if we consider proference as a genus, then there are two species – propensity and preference – which, by mutual and permanent adaptation, co-evolve and thus lead to the evolution of proference. This conceptual niche of co-evolution within the broader co-evolution financial market-cultural geodesic has its importance in the body of the study, as it not only allows a grounding of adaptive preference and the adaptive process in which preference is thus engaged but also has broader methodological implications: within the methodological holism that we adopt in our research, we accept a niche of methodological individualism

that maintains a micro-level line of macro-level grounding in the matter of adaptive preference;

- the fact that propensity underlies preference should not lead to the conclusion that preference is confused with the set of conditions under which propensity is manifested (objectified). As we have already pointed out, the set of conditions, although local, is itself manifested within the cultural geodesic. Thus, propensity generates that preference which is 'chosen' (selected) by the environment, an environment which has been given the name of cultural geodesic;
- propensity is the cause of preference, but preference is not the occasion of propensity;[99]
- propensity can generate several preferences (possibly incompatible two by two), but a preference cannot be the effect of a 'concert of propensities;
- adaptive preference has a margin of variation which does not constitute pressure on propensity – a 'dead zone' of variation, variation in preference which exceeds the 'dead zone' can also affect propensity (whose objectivity is, as noted earlier, of the social type, i.e., of the inter-subjectivity type, it is not an objective objectivity, but an objectified objectivity).

A synoptic picture of the operation of the *MA*2 assumption can be represented as in Figure 3.5.

(*MA*3): propensity represented by preference is the cause of (subjective) *probability* assignment in the choice of trading strategy. *Nota bene*: from a pathway dependence perspective, *MA*3 is associated with *TA*1 and *TA*2 .

This is the third functional link (after propensity and preference) in the construction of the equational model (see part 2 of Chapter 3) of adaptive preference. *MA*3 returns, in fact, to the idea which has been presented (and discussed) since the first chapter, namely, that preference (rigid, as in EMH, or adaptive via the

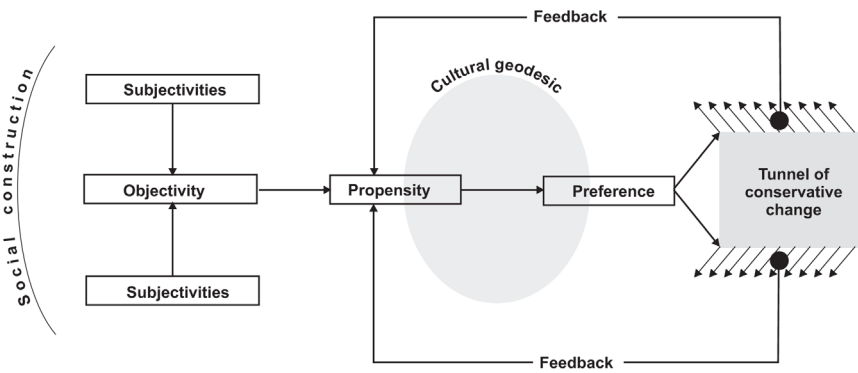

Figure 3.5 General scheme of functioning of the assumption *MA*2.

Source: Authors.

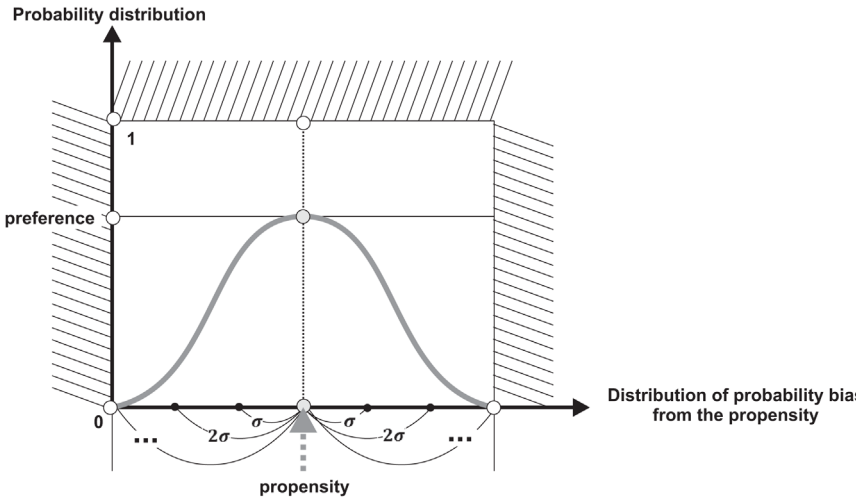

Figure 3.6 General scheme of functioning of the assumption *MA*3.
Source: Authors.

financial market, as in AMH, or directly adaptive, as we will propose in the form of APH) is a manifestation of propensity.

*MA*3 implies that preference is the subjective form of manifestation of a property with an accentuated objective character – that is, propensity (*Nota bene*: as we have stated several times, we are talking here about a social objectivity, i.e., an objectification of inter-subjectivity). More concretely, given that, from a logical point of view, preference is manifested by the granting of a maximum probability[100] (among all those granted) for a given hypostasis of an event, from a given field of events, it follows that propensity simply 'inflates' a given probability, and this is constituted on the basis of the choice that the individual makes in a given context. To draw a parallel with Gauss's famous 'bell', one could say that the probabilities[101] in a probability distribution are ordered, under the impact of propensity, just like such a 'bell', in the centre of the probability distribution, that is, at the point of maximum probability, being the very preference generated by propensity. A synoptic picture in this sense can be seen in Figure 3.6.

*MA*3 does, however, raise a number of issues that will need to be addressed in a way that allows for factual testing. Otherwise, one might consider that we have introduced metaphysical elements[102] into our model (both logical and equational). To avoid (at least as an intention) this risk, we make the following considerations:

- the propensity analysis as done independently of the (subjective) probability it is likely to generate/cause. Somehow, propensity exists independently of whether or not it will cause a preference, which in turn manifests

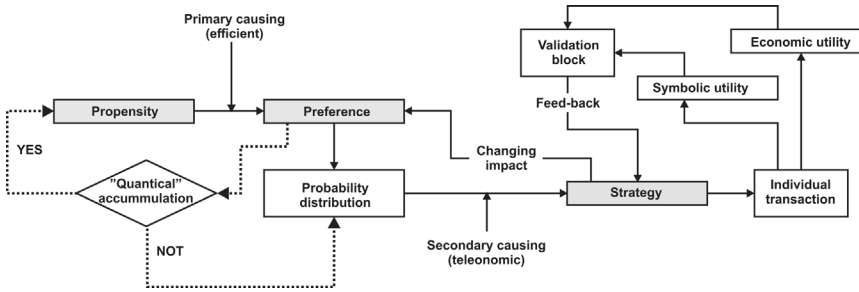

Figure 3.7 The 'quantum' behaviour of *MA*3.

Source: Authors.

itself in maximizing one of the probabilities in the (exhaustive) probability distribution;

- co-evolution[103] functioning between probability and preference, which means that the mutual feedback rules between probability and preference need to be examined. This examination must be carried out bearing in mind that probability and preference are not mutually autonomous (just as propensity and preference are mutually autonomous) so that the reaction from probability to preference could be considered to be of the nature of co-adaptation rather than co-evolution;
- in any case, in our view, the impact of preference on propensity (if it is to be accepted)[104] occurs in a discrete (not continuous) way or, with a term less commonly used in economic research, in a quantified way, or in a quantum way. This means that the process of preference-propensity co-adaptation turns into a reverse reaction from preference to propensity only upon reaching a certain (quantum) amount of variation in preference from its initial propensity-generated state.

These qualitative considerations can be represented as in Figure 3.7.

(*MA*4): the allocation of probabilities, generated by preference, is of Bayesian type, and their *a priori* distribution is made, under conditions of uncertainty, on the basis of Laplace's principle of insufficien reasoning. *Nota bene*: from a pathway dependence perspective, *MA*4 is associated with *TA*1 and *TA*2 .

This assumption, although methodological, is 'almost' an instrumental one, since it indicates the concrete operational way in which one arrives at probability, from propensity, through preference manifested in behaviour (choice of the trading strategy), to probability. As mentioned earlier, the probability that 'chooses' the preference is a subjective probability. Technically, this subjective probability is Bayesian.[105] More precisely, it is the so-called Bayesian *a priori* probability which, under the impact of new information (generated by behaviours, either of its own or of other economic agents acting in the financial market), is transformed into Bayesian *a posteriori* probability. This transformation is, so to speak, the key

to equational modelling of adaptive preference (and will be dealt with in Volume 2 to be released). However, with respect to the constitution of the Bayesian *a priori* probability distribution, we will, in what follows, make some basic considerations that are intended to clarify, to at least a reasonable extent, how we see this methodological assumption working.

The 'lower' limit of how to construct the Bayesian *a priori* probability distribution is the application of Laplace's principle called *the principle of insufficient reason*.[106] It requires that, under conditions of complete uncertainty, one assigns the same numerical probability value to any hypostasis of the event in question, taking care of course to respect the Kolmogorov assumptions (any probability is positive, and the sum of probabilities is 1).

These subjective probabilities are generated by what we have called proference (an operator integrating propensity with preference). As, however, preference is described as being associated with the maximum probability that an economic agent confers on a given hypostasis of an event, certain ambiguities arise which we shall try to eliminate.

In our view, preference (or, more precisely, proference) does not choose a particular hypostasis (occurrence) of a given event but a particular trading strategy from among those available. Let us admit a set of trading strategies, TS_i (with $i \in \mathbb{N}$, $i = \overline{1,n}$). According to the principle of insufficien reason, the *a priori* (Bayesian) probability distribution is as follows (*Nota bene*: we denote the *a priori* distribution by D_{ap}, and the *a posteriori* distribution by D^{ap}):

$$D_{ap} = \begin{pmatrix} TS_1 & TS_2 & \dots & TS_n \\ p_1 & p_2 & \dots & p_n \end{pmatrix}$$

with Kolmogorov conditions: (a) $(\forall) i \in \mathbb{N}$, $p_i \geq 0$; (b) $\sum_{i=1}^{n} p_i = 1$; moreover, $p_i = p_j$, $(\forall) i, j \in \mathbb{N}$, for $i = \overline{1,n}$, and $j = \overline{1,n}$.

Be the propensity p, to which the preference $\mathcal{P}$ corresponds; we define the proferential field (by analogy with the probabilistic field) as

$$\mathbb{P} = \{p, \mathfrak{f}, \mathcal{P}\}$$

where $\mathfrak{f}$ is a function associating a preference with a propensity: $\mathcal{P} = \mathfrak{f}(p)$.

An *a priori* probability distribution is therefore a Laplace distribution that is 'altered' by preference. Preference is therefore an operator that de-homogenizes uncertainty – the last is no longer complete but incomplete.[107] Note that uncertainty is not reduced through information but through behaviour (that's right, 'programmed' behaviour based on propensity).

Therefore, an *a priori* Bayesian probability distribution conditional on the propensity $\mathbb{P}$ will have to be written as follows:

$$D_{ap} \mid \mathbb{P} = \begin{pmatrix} TS_1 & TS_2 & \dots & TS_{k-1} & \boldsymbol{TS_k} & TS_{k+1} & \dots & TS_n \\ p_1 & p_2 & \dots & p_{k-1} & \boldsymbol{p}_*^{\mathbb{P}} & p_{k+1} & \dots & p_n \end{pmatrix}$$

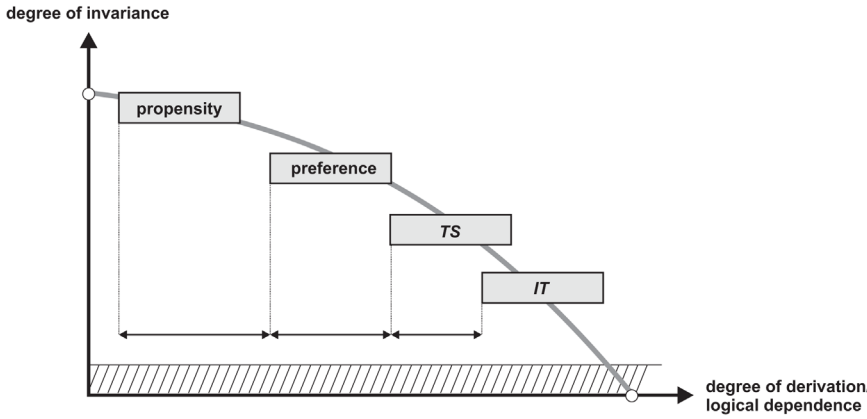

Figure 3.8 Inverse relationship between degree of invariance and degree of logical dependence in the operation of the assumption *MA*4.

Source: Authors.

so that

$$p_k = p_*^{\mathbb{P}}$$

$$p_*^{\mathbb{P}} > p_j \text{, for } (\forall) j \neq k$$

$$\sum_{j \neq k} p_j + p_*^{\mathbb{P}} = 1$$

Nota bene: note that the reasoning here verifies the graphical suggestion in Figure 3.7[108] that, at a given propensity, preference manifests itself by assigning the maximum probability in the given probability distribution.

The impossibility of allocating objective probabilities (i.e., frequential-type probabilities) results from the fact that individual transactions are always logically unique, although the trading strategy has some stability (until it is selected by the environment, either by acceptance or by rejection). The stability of *TS* is explained by the fact that preference is in turn relatively stable based on the stability of propensity. Moreover, it is immediately observed that we have diffe - ent degrees of stability (hence different degrees or periods of invariance) for the four correlated concepts: propensity, preference, *TS*, *IT*, a distinction suggested synoptically by Figure 3.8.

The mix information-behaviour on the financial market

Preliminaries

Neither Fama nor the EMH proponents/critics have examined from a logically, psychologically, anthropologically, and sociologically point of view, the

setting up of information in the financial market and, obviously, even less, its impact on financial behaviour (i.e., on the decision-action pair). Having 'decreed' the complete integration of available information into price, they were content to test this exclusively empirically (usually on the basis of examining correlation in the time series of prices – regardless of the statistical sophistication of this examination). The BMH has, of course, a natural inclination towards examining the real, psychological, and evolutionary aspects of financial behaviour, but as shown earlier, even this model has failed to present a coherent theory of information integration into behaviour. As for the AMH, which aspires to bring EMH and BMH, together, our view is that it is still at the conjectural stage (of course, inspiring potentially productive ideas) and needs to be further structured.

In this part of the chapter, we will try, from the perspective of adaptive preference, to find/propose quantitative equation/inequation-like relationships on how propensity and preference (i.e., their mix: *proference*) integrate information and behaviour on the financial market.

We have referred in previous studies to the fact that the primacy of information over behaviour is not a certainty and that, without going to the diametrically opposite side – the primacy of behaviour over information – we must operate a combination (a mix) between the two categories. The reasons for such a mix are at least the following:

- the economic market (particularly the financial market) functions through communication between its actors (buyers/investors and sellers);
- this communication takes place not only between the two 'blocks' – buyers and sellers – but also within each 'block' – between buyers and between sellers;[109]
- coalitions[110] (trusts, syndicates, etc.) can form among buyers, respectively among sellers, leading to aggregated individuals (e.g., organizations) acting in concert on the financial market (investment funds, mutual funds, index unds, etc.);
- all of the above leads to the conclusion that these actions cannot take place without communication between the participants in these processes. And communication can only take place through information;
- information is therefore the ultimate vehicle through which communication takes place. But if it is a vehicle of last resort, it means that there are non-informational sources of communication which ultimately (barely) take the form of information, these sources of communication being of intermediate or, at the very least, first resort. This last point will be addressed next (Dinga, 2021):
    - firstl , there can be *formal information* (*FI*): this is the information (which we can also call geodesic information)[111] equally available to all individuals, whether operating or not operating in the financial market, that is, the information available in the regulatory framework of society. This information is integrated ex ante into any decision/behaviour, that is, in full, immediately and without search costs;[112]

- secondly, there may be *implicit information* (*II*): this is information that refers to events (and is contained, *in nuce*, in events) on the financial market, available to all attentive and reflective economic agents (these qualities of economic agents do not, of course, imply any connotation of financial competence) or what, in the specialty literature, is even called information of event;[113] implicit information is quasi-free, unlike formal information, because it involves what in economic theory is called implicit cost[114] – in the case under discussion it is the cost of 'transforming' (more precisely, 'translating') the observed event into usable information for one's own decision and behaviour;[115]
- thirdly, there may be *bound information* (*BI*): this is information that can (and must) be bought – either by ordering studies from firms specialized in financial market research or, in illegal cases, by acquiring it through corruption, bribery, or theft (in the latter case, it is a variety of bound information, i.e., the inside information of an agent or organization).

Obviously, bound information is information that is not free of charge, as it involves both a search cost (paying for studies to acquire the information) and the cost of (covering) the risk of be discovered the illegal way of acquiring inside information (e.g., if the information is stolen).

Of the three categories of information, implicit information refers… explicitly to behaviour. In other words, implicit information is not information *per se* (like formal information or bound information) but inferred information, namely, inferred from behaviour. This is exactly the sense in which we say (as we have said in previous studies) that on the financial market, there can be a primacy of behaviour over information. Implicit information is therefore an information that is produced by the (potential)[116] user of that information himself, by idiosyncratic means: intuition (flair), rationality calculation (e.g., Capital Asset Pricing Model (CAPM), Black-Scholes-Merton (BSM)), and coincidence (luck, chance).

As it will be seen later, the 'fate' of formal/free information (partially also of the other two categories of information) depends on the preference/proference of the agent concerned.[117] A synoptic systematization of the information categories can be made in the form of a Karnaugh diagram, which simultaneously qualifies, from the perspective of three criteria, each type of information[118] (Figure 3.9).

So, on the financial market, an agent will use a mix of three categories of information, one of which – implicit information – is 'fabricated' by the user of that information himself, with behaviour as the primary or first source. Of the three categories of information, only one is free – formal information – and of the other two categories of information that require costs, the costliest is the bound information. In the case of the latter category of information, the risk of acquiring the information is an additional sui generis cost, thus increasing the required return on the individual commercial transaction based on the informational mix.[119]

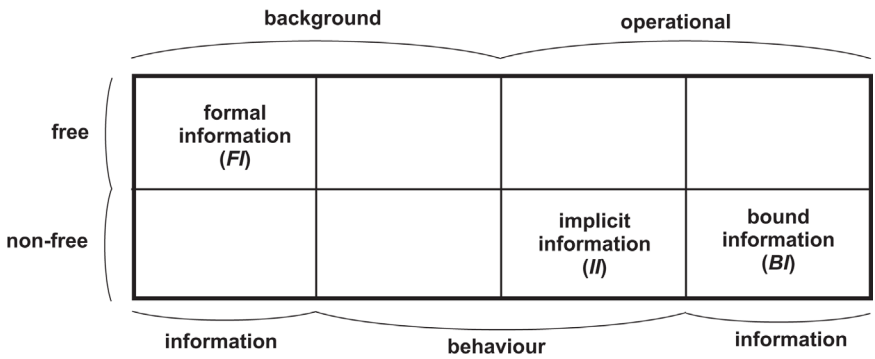

Figure 3.9 Typology of information on the financial market.

Source: Authors.

General notations

- i : information;
- i_x : formal information;
- i_y : implicit information;
- i_z : bound information;
- c_{i_j} : cost of acquiring information, with $j \in \{x, y, z\}$ (*Nota bene*: it is presumed that the acquiring of formal information is free of charge: $c_x = 0$);
- c_{i_y} : cost associated with acquiring implicit information;
- c_{i_z} : cost associated with the acquiring of bound information (including the cost of covering the transaction risk);
- m_d : informational mix available on the financial market;
- m_a : informational mix accessible to the agent;
- m_u : informational mix accessed by agent;
- c_{z1} : cost associated with the lawful purchase of information (e.g., consulting studies);[120]
- c_{z2} : cost associated with illegal purchase of information (bribery, corruption);
- c_{z3} : cost associated with information theft;[121]
- c_{z4} : cost associated with the coverage (*ex ante*) of the risk of acquiring information of the types c_{z2} and c_{z3}.

Available informational mix

Conceptual aspects

Individuals, and therefore economic agents who make commercial transactions on the financial market, are immersed (literally) in a 'large' information that is constantly occurring in the social environment, and thus also on the financial market. In this context, each agent is simultaneously a consumer and a producer of

information. The production of information is carried out either actively (e.g., through marketing activities) or, in particular, passively, by simple behaviour on the financial market. The primitive concept of information or informational mix (given the three distinct categories of information identified earlier) refers to the information available (available informational mix), which is why our analysis of the relationship between information and behaviour begins with this type of mix.

Specific notation

- α_x : the share with which formal information enters the available informational mix;
- α_y : the share with which the implicit information enters the available informational mix;
- α_z : the share with which the bound information enters the available informational mix;
- β : the depth of the financial market, as a relative measure (in the form of a coefficient of the monetary value of transactions carried out on the financial market (weights in GDP);
- A : the minimum limit of financial market regulation, below which any decrease in regulation leads to anomie; this can be called *the regulation trap*.[122]

Quantitative relationships

$$i \in \{i_x, i_y, i_z\}$$

$$m_d = i_x \cdot \alpha_x + i_y \cdot \alpha_y + i_z \cdot \alpha_z, \text{ with } \alpha_x + \alpha_y + \alpha_z = 1, \text{ and } \alpha_{(\cdot)} \in \mathbb{N}$$

$$c_z = \sum_{k=1}^{4} c_{zk}$$

Discussion

Sum formation curves $\alpha_x + \alpha_y + \alpha_z$ in information process on the financial market are represented (from a purely qualitative point of view) in Figure 3.10.

α_x is a downward and convex curve because as the financial market deepens (i.e., more and more financial securities are trading on the market), the share of formal information decreases to a lower limit below which the anomie appears.[123] Therefore, the share of public regulation of the financial market decreases as the market, as a result of the increasing depth, self-regulates;[124]

$$\text{equation: } \alpha_x = \frac{A}{\beta}, \text{ where } 0 < A < 1, \text{ and } \beta \neq 0; \text{ really, } \lim_{\beta \nearrow 1} \alpha_x = A$$

α_z is a polynomial curve of the order 2, concave. As the financial market increases from zero, the need for bound information increases relatively rapidly from zero to a maximum of the sum of the weights of the three categories of

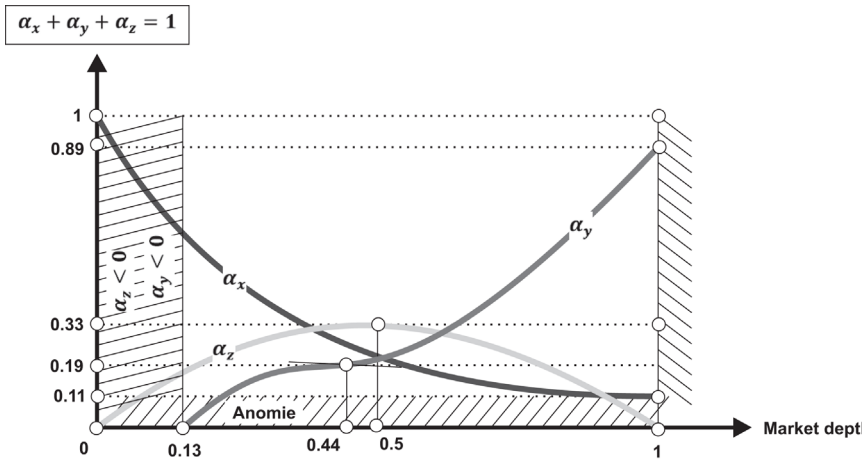

Figure 3.10 Sum formation curves $\alpha_x + \alpha_y + \alpha_z$.

Source: Authors.

information,[125] that is, up to the value 0.33, after which the increase in market depth reduces the importance of bound information to the null limit, to the point where the market depth is maximum.

$$\text{equation: } \alpha_z = m + n \cdot \beta + p \cdot \beta^2$$

Considering the condition $\alpha_x + \alpha_y + \alpha_z = 1$, however, one of the three weights is the difference up to 1 of the sum of the other two. We will consider α_x and α_z as given, so:

$\alpha_y = 1 - \alpha_x - \alpha_z$. Therefore, we will have (under the initial conditions) $A = 0.11$

$$\alpha_y = 1 - \frac{A}{\beta} - m - n \cdot \beta - p \cdot \beta^2$$

We will determine, on the basis of the initial conditions (in fact, the hypothesis regarding the lexicographic ordering of the three weights of the information categories), the values of the parameters A, m, n, and p:

- (1) in the case of the equation α_x: $A = 0.11$ i.e., $a_x = \dfrac{0.11}{\beta}$
- (2) in the case of the equation α_z:
  - for $\beta = 0$, we have, $\alpha_z = 0$, so $m = 0$;
  - for $\beta = 1$, we have $\alpha_z = 0$, so $n + p = 0$;

- $\alpha_z = 0.33$ implies $n + 2 \cdot p \cdot \beta = 0$, i.e., $\beta^* = -\frac{n}{2p}$ (where with β^* noted the value of β for which $\alpha_z = 0.33$);
- so: $n = 1.32$, and $p = -1.32$;
- therefore, the particular equation α_z is $\alpha_z = 1.32 \cdot \beta - 1.32 \cdot \beta^2$ (it is immediately observed that α_z is a polynomial function of the order 2 concave, because $\frac{\partial^2 a_z}{\partial \beta^2} = -2.64 < 0$);

- (3) in the case of the equation a_y we have:

$$\alpha_z = 1 - \frac{0.11}{\beta} - 1.32 \cdot \beta + 1.32 \cdot \beta^2 = \frac{-0.11 + \beta - 1.32 \cdot \beta^2 + 1.32 \cdot \beta^3}{\beta}$$

Functions α_x, α_y and α_z will take the shape[126] represented in Figures 3.11–3.13.

Nota bene: it is interesting to observe that the need for self-produced information (implicit information) is increasingly slowed with the increase in the depth of the financial market from low values.

Let us examine, in qualitative terms, the curve α_y:

- as a general allure (and with sufficien precautions) appears to be a 'mirror' logistic curve compared to the axis of abscises, in relation to a 'normal' logistic curve;[127]

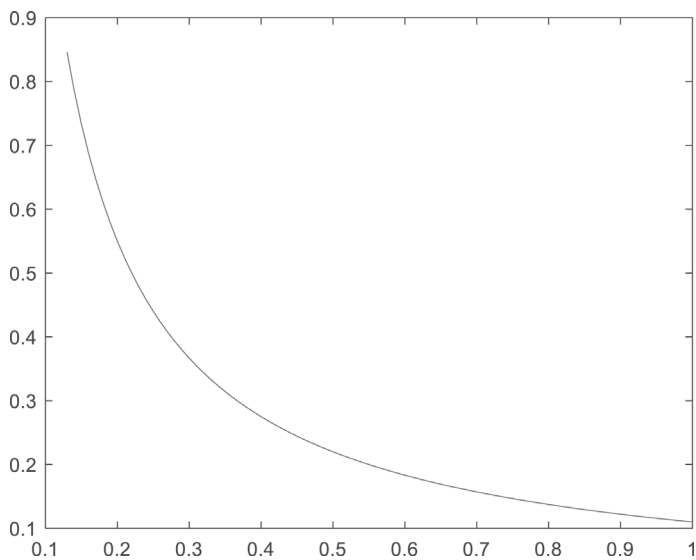

Figure 3.11 Curve α_x.

Source: Authors.

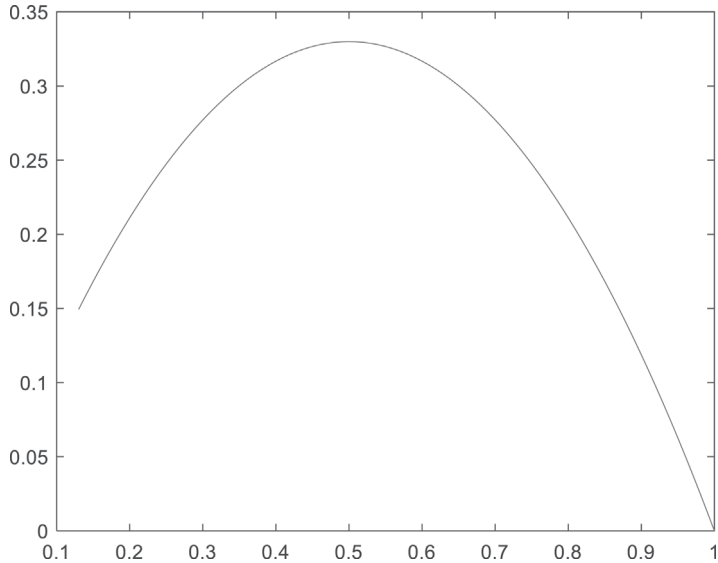

Figure 3.12 Curve α_z.

Source: Authors.

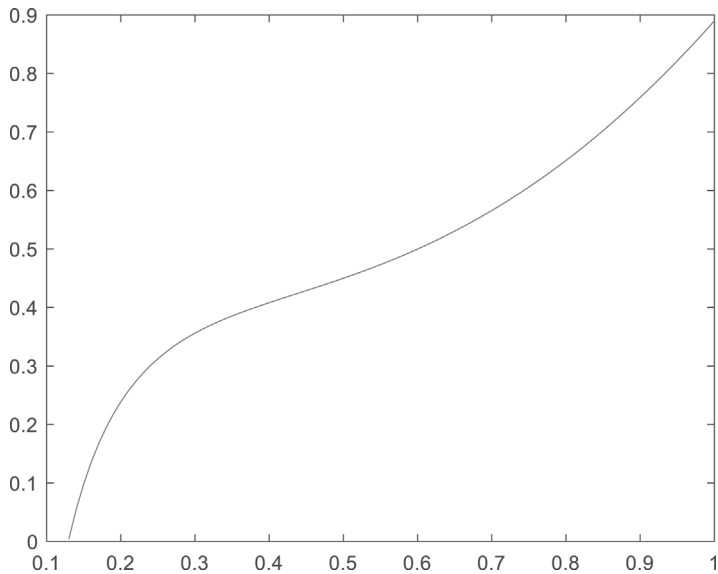

Figure 3.13 Curve α_y.

Source: Authors.

- curve has an inflection point,[128] in $\beta = 0.44$. This was determined by solving the equation obtained as the second derivative of the function α_y;
- the value of $\alpha_y(0.44) = 0.19$, so the inflection point has the coordinates $(\beta, \alpha_y) = (0.44; 0.19)$.

Based on this, we can now write down the formal/analytical relationship of the available informational mix:

$$m_d = i_x \cdot \frac{0.11}{\beta} - i_y \cdot \left(\frac{0.11 - \beta + 1.32 \cdot \beta^2 - 1.32 \cdot \beta^3}{\beta} \right) + i_z \cdot \left(1.32 \cdot \beta - 1.32 \cdot \beta^2 \right) \text{ or}$$

$$m_d = \frac{0.11 \cdot (i_x - i_y)}{\beta} + i_y - 1.32 \cdot \beta \cdot (1 - \beta) \cdot (i_y - i_z)$$

The following considerations on the equation m_d may be relevant:

a. for $\beta \searrow 0$, $\lim\limits_{\beta \searrow 0} m_d = \begin{cases} \infty, \textit{for } i_x > i_y \\ -\infty, \textit{for } i_x < i_y \end{cases}$

b. for $\beta = 1$, $m_d(1) = 0.11 \cdot i_x + 0.89 \cdot i_y$

c. The first derivative of the function $m_d(\beta) = \frac{\partial [m_d(\beta)]}{\partial \beta}$ will be calculated for the four significant cases concerning the quantitative ratio between i_x , i_y , and i_z (*Nota bene*: the numerical values here are simply stylized, relevant only to the purely qualitative or didactical reasoning in this section):[129]

(c1) $i_x = 3$; $i_y = 2$; $i_z = 1$, that is, $(i_x - i_y > 0)$ and $(i_y - i_z > 0)$

(c2) $i_x = 3$; $i_y = 2$; $i_z = 3$, that is, $(i_x - i_y > 0)$ and $(i_y - i_z < 0)$

(c3) $i_x = 3$; $i_y = 4$; $i_z = 3$, that is, $(i_x - i_y < 0)$ and $(i_y - i_z > 0)$

(c4) $i_x = 3$; $i_y = 4$; $i_z = 5$, that is, $(i_x - i_y < 0)$ and $(i_y - i_z < 0)$

so:

for (c1):

$$m_d(\beta) = \frac{0.11}{\beta} \cdot (1) + 2 - 1.32 \cdot \beta \cdot (1 - \beta) \cdot (1) = \frac{0.11}{\beta} + 2 - 1.32 \cdot \beta \cdot (1 - \beta)$$

$$\frac{\partial [m_d(\beta)]}{\partial \beta} = 1.32 \cdot \beta - 1.32 \cdot \beta^2 = 1.32 \cdot \beta \cdot (1 - \beta) > 0 \text{ , for } (\forall) \beta$$

for (c2)

$$m_d(\beta) = \frac{0.11}{\beta} \cdot (1) + 2 - 1.32 \cdot \beta \cdot (1-\beta) \cdot (-1) = \frac{0.11}{\beta} + 2 + 1.32 \cdot \beta \cdot (1-\beta)$$

$$\frac{\partial [m_d(\beta)]}{\partial \beta} = 1.32 - 0.11 \cdot \beta^2 - 2.64 \cdot \beta < 0 \text{ , for } (\forall)\beta$$

for (c3)

$$m_d(\beta) = \frac{0.11}{\beta} \cdot (-1) + 4 - 1.32 \cdot \beta \cdot (1-\beta) \cdot (1) = -\frac{0.11}{\beta} + 4 - 1.32 \cdot \beta \cdot (1-\beta)$$

$$\frac{\partial [m_d(\beta)]}{\partial \beta} = 2.64 \cdot \beta + 0.11 \cdot \beta^2 - 1.32$$

for (c4)

$$m_d(\beta) = \frac{0.11}{\beta} \cdot (-1) + 4 - 1.32 \cdot \beta \cdot (1-\beta) \cdot (-1) = -\frac{0.11}{\beta} + 4 + 1.32 \cdot \beta \cdot (1-\beta)$$

$$\frac{\partial [m_d(\beta)]}{\partial \beta} = 0.11 \cdot \beta^2 - 2.64 \cdot \beta + 1.32$$

Graphically, the curves discussed are represented as follows:

- Figure 3.14: m_d for (c1);
- Figure 3.15: $\frac{\partial [m_d(\beta)]}{\partial \beta}$ for (c1);
- Figure 3.16: m_d for (c2);
- Figure 3.17: $\frac{\partial [m_d(\beta)]}{\partial \beta}$ for (c2);
- Figure 3.18: m_d for (c3);
- Figure 3.19: $\frac{\partial [m_d(\beta)]}{\partial \beta}$ for (c3);
- Figure 3.20: m_d for (c4);
- Figure 3.21: $\frac{\partial [m_d(\beta)]}{\partial \beta}$ for (c4).

d. In the equation m_d two weighting factors emerge that need to be further described and examined:

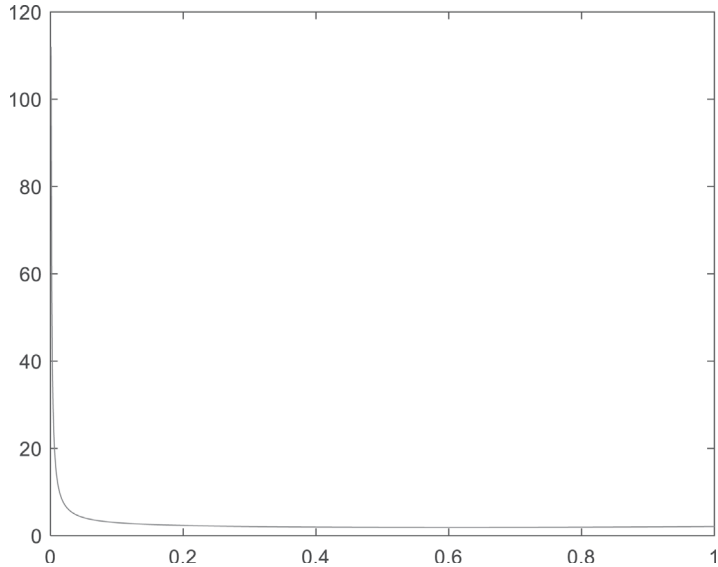

Figure 3.14 Curve m_d for the case (c1).

Source: Authors.

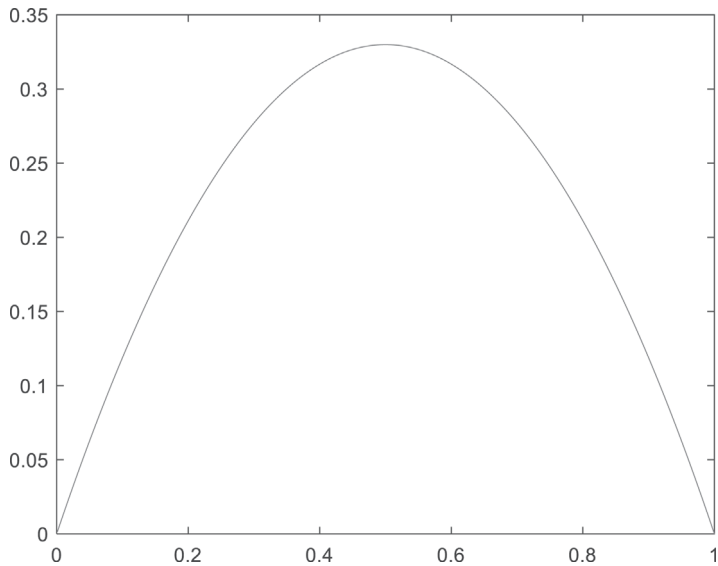

Figure 3.15 Curve $\frac{\partial\left[m_d(\beta)\right]}{\partial\beta}$ for the case (c1).

Source: Authors.

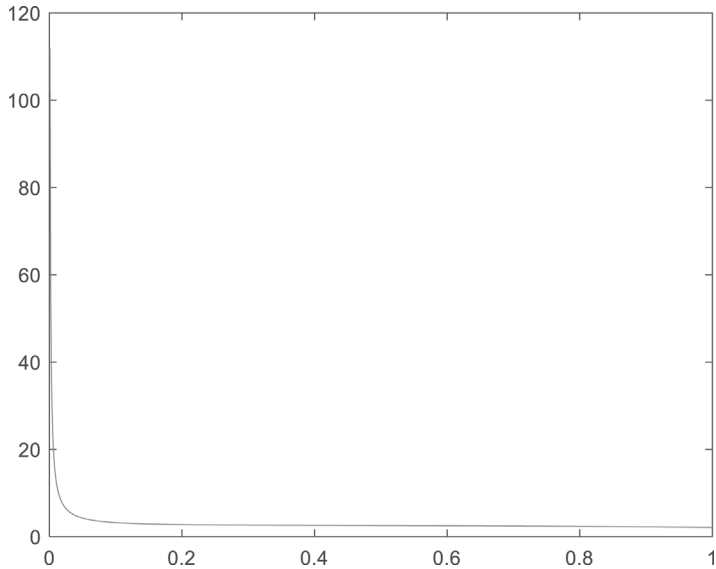

Figure 3.16 Curve m_d for the case (c2).

Source: Authors.

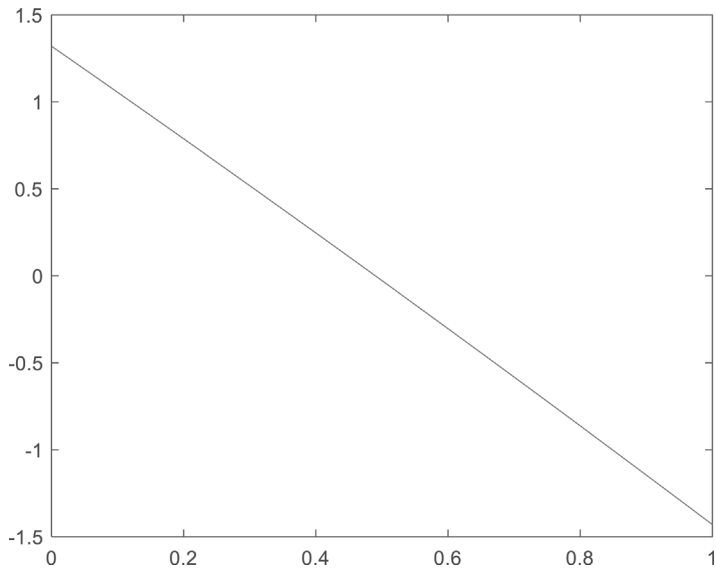

Figure 3.17 Curve $\frac{\partial\left[m_d(\beta)\right]}{\partial\beta}$ for the case (c2).

Source: Authors.

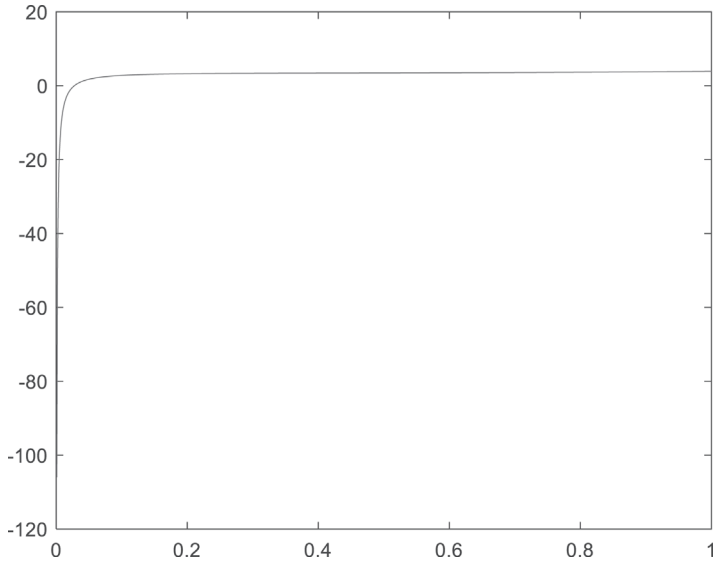

Figure 3.18 Curve m_d for the case (c3).

Source: Authors.

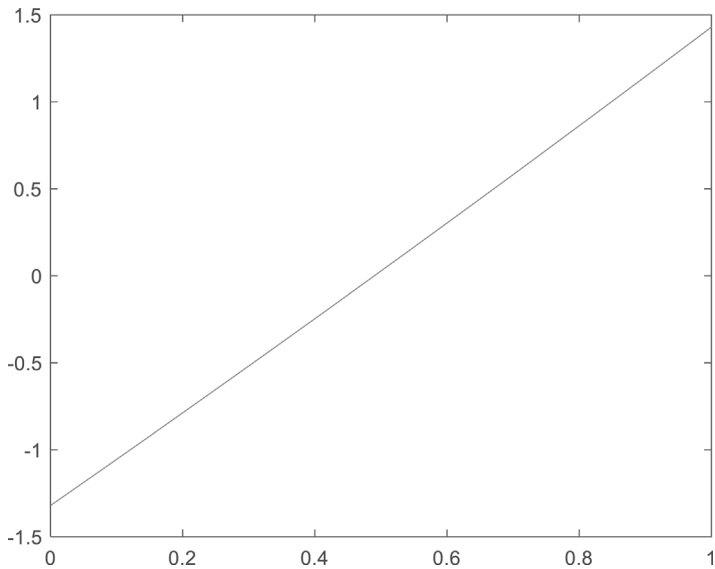

Figure 3.19 Curve $\frac{\partial\left[m_d(\beta)\right]}{\partial\beta}$ for the case (c3).

Source: Authors.

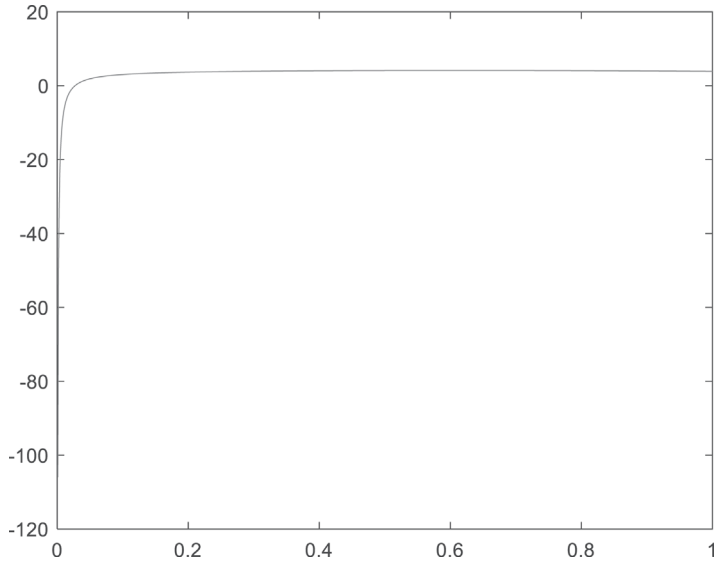

Figure 3.20 Curve m_d for the case (c4).

Source: Authors.

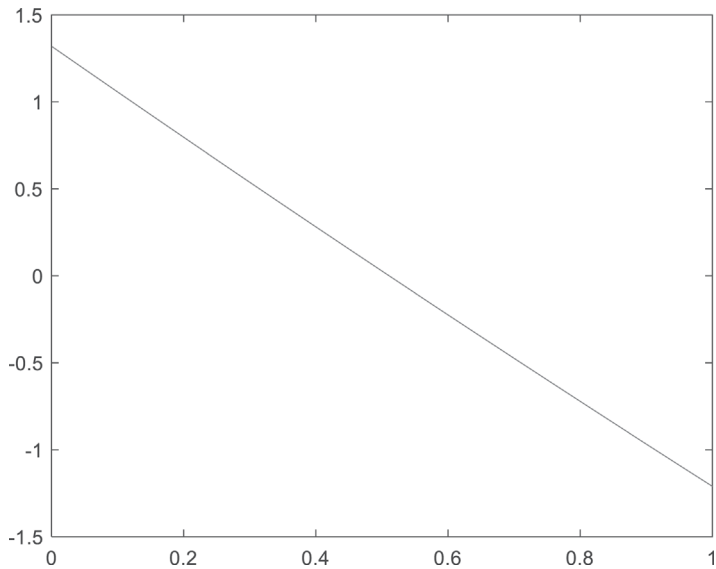

Figure 3.21 Curve $\dfrac{\partial\left[m_d(\beta)\right]}{\partial\beta}$ for the case (c4).

Source: Authors.

- $\left(i_x - i_y\right)$, that is, the difference between the amount of formal information (presumed to be accessible at no cost) and the amount of implicit information (presumed to be that category of information that involves internal costs of inference from the observed behaviour of other agents in the financial market), which we note with δ_1. This difference, which we can call *the public information gap*, indicates, by its numerical value, the position of market depth in terms of the first two categories of information;
- $\left(i_y - i_z\right)$, that is, the differ nce between the amount of implicit information and the amount of bound information (presumed to be that category of information involving external but internalized costs of acquiring information otherwise inaccessible freely), which we note by δ_2. This differen e, which we can call *the private information gap*, indicates, by its numerical value, the position of market depth in terms of the last two categories of information;
- so, we have, with the new notations: $m_d = \frac{0.11 \cdot \delta_1}{\beta} + i_y - 1.32 \cdot \beta \cdot \left(1 - \beta\right) \cdot \delta_2$.

Short conclusions

We have discussed the typology of information available on the financial market, that is, exactly the concept that Fama had in mind when it 'demanded' that the price of financial securities fully, immediately, and without transaction costs integrate the information available on the market.[130] Thus, we found the existence of an informational mix consisting of three categories of information – formal, implicit, and bound – each of them having its own mathematical function of evolution depending on the depth of the financial market, which leads to different kinematics of the weights with which they enter into the formation of the informational mix available on the financial market – formal information: a hyperbolic curve; implicit information: a symmetric curve of a logistic curve with respect to the abscissa axis; bound information: a concave parabolic curve.

Unlike Fama, who did not examine the structure of the informational mix on the financial market[131] and did not analyse in depth the different kinematics of the contributions of the different categories of information in the formation of the available informational mix, we have carried out these analyses, which are absolutely necessary for the following approaches. In addition, we are interested in two other categories of informational mixes (besides the available informational mix), which take into account the (real) characteristics of economic agents.[132]

Accessible informational mix

Conceptual aspects

This time we are interested in the informational flow accessible to the economic agent because, unlike the EMH case, we consider (along with Simon, Lo, and other realist researchers of the economic market, in general, and the financial

market, in particular) that economic agents have different access to the available informational flow (more precisely, as shown earlier, to the informational mix formed by the three categories of information). We will develop this idea further.

The difference in access to the informational flow on the financial market is caused by two factors acting simultaneously: (a) the objective factor and (b) the subjective factor. The *objective* factor refers to the very nature/category of information. Thus, in our view, the accessibility of formal information is almost the same for any economic agent and, consequently, can be considered to be the same[133] for economic agents operating in a given system or market. The *subjective* factor refers to the characteristics of the economic agent (whether individual or organizational). The subjective factor breaks down into two (subjective) sub-factors:

1 *ethical competence of the* economic agent – some economic agents have a greater inclination than others in terms of the accessibility of bound information (i.e., information obtained by fraud);[134]
2 *the resolutory* or cognitive *competence* of the economic agent – some agents are better than others at extracting useful information from observing financial market behaviour. Similarly, some economic agents are more competent than others in 'deciphering' financial market signals (more generally, in deciphering the financial market behaviour of other economic agents), that is, they have a wider scope than others with respect to the accessibility of implicit information.[135]

These two factors mean that at the same available informational flow (mix) (m_d), the accessible informational flow (mix) (m_a) differs from one economic agent to another. In addition, the accessible informational mix rarely overlaps (quantitative, structural, qualitative, and temporal[136]) with the available informational mix.

Some working hypotheses are needed to examine the accessible informational mix:

1 we are looking only at individuals (physical or organizational) acting/trading on the financial market, not at all individuals from the given economic/social system. In this way, we eliminate cases where some individuals are simply not interested on financial information, that is, individuals for whom the accessibility/non-accessibility of this type of information is completely irrelevant for their decision and behaviour;
2 if financial individuals[137] were homogeneous (e.g., as required by the EMH), then their distribution would be quasi-identical at a given depth of the financial market, with the distribution of the weights with which each category of information enters the available informational mix;
3 we will adopt the heterogeneity hypothesis of financial individuals; therefore, the distribution of financial individuals will differ from the distribution of α (with which we note the distribution, depending on the depth of the market – noted with β –, of the three categories of information previously identified);

4 the accessibility of the available informational mix will therefore differ from one financial individual to another, depending on a characteristic of the individual in question, which we want to call *informational permeability*. By informational permeability, we mean a kind of information sensitivity (more precisely, sensitivity to information) characterized by the following sufficiency predicates:

   - the agent is aware of the existence of the available information – we call this capacity *observational competence*;
   - the agent is able (possesses *the resolutory competence*, mentioned earlier) to extract, from the available information, information that is significant for him (for his economic/financial interest)

Nota bene: the informational permeability of the financial individual (agent) has a passive status; the economic agent could access/use the available information, if he so decides. It therefore does not have an actual status. In other words, the information permeability of the agent is a possibility. Moreover, a fundamental point about informational permeability needs to be made here – it is *not* of the nature of propensity (a concept discussed in Assumptions) but, as mentioned earlier, of the nature of possibility.

A problem symmetric to the depth-market dependence of the weight of each category of information in the available informational mix is the depth-market dependence of the competence of economic agents. In this context, we advance here *three hypotheses*[138] on which we want to build the accessibility of the informational mix in the financial market: (1) *passive hypothesis* (*PH*): the economic agent's observational competence is described by a concave parabolic function; (2) *active hypothesis* (*AH*): the economic agent's resolutory competence is described by a convex parabolic function; and (3) *situational hypothesis* (*SH*): the economic agent's ethical competence is described by a decreasing hyperbolic function.

We will make some (minimal) clarifications on the justification, from a behavioural perspective (simultaneously, rational, behaviourist, and evolutionary), of the three hypotheses.

PH: the economic agent's observational competence is described by a concave parabolic function.[139] This means that at relatively low levels of market depth, as market depth increases, observational competence also increases but slowly so that after reaching a maximum, observational competence starts to decrease and then accelerates. The explanation is (in our view) as follows: as the market deepens, the 'population' of economic agents and, more importantly, of transactions in the financial market increases, making it more difficul to observe market events, so that the agent in question will soon become informationally suffocated and, as a result, unable to maintain the previous observational standard.

AH: the resolutory competence of the economic agent is described by a convex parabolic function. This means that, at relatively low levels of market depth, the agent's resolutory (cognitive) competence is very high, especially since, according to the passive hypothesis, the amount of information he observes (generated

by financial market events) is relatively small. But as the depth of the market increases (and, correlatively, according to the passive hypothesis, the amount of observed information also increases, although non-linearly, as we have shown), it becomes more and more difficul for the agent to process the increasingly abundant information, especially as financial events also become more complex with increasing market depth. Thus, resolutory competence declines (accelerating) to a minimum and then begins to increase (also accelerating) as the financial market continues to deepen. What is the explanation for this 'revival' of resolutory competence? Our explanation is as follows:

- when the financial market deepens from low values of this depth (near the origin of the coordinate axes in Figure 3.22), the difficult of 'translating' the signals transmitted by the various events generated by the actions of economic agents increases;
- however, after a certain level of market depth, as depth continues to increase, it is precisely this greater depth that leads to the formation of patterns that become intelligible to the economic agent in question. Somehow what is called *categorical knowledge*[140] in cognitive psychology occurs – the economic agent knows more with less information, because the observed information (which becomes increasingly difficul to observe over time, as the observational competence curve shows) is (almost) automatically interpreted on the basis of patterns that it has already deduced from the market's own functioning at increasing depths;
- this explains the (apparent) paradox resulting from Figure 3.22: although the economic agent's observational competence decreases as the depth of the financial market increases, however, his resolutory (cognitive) competence increases.[141]

SH: the ethical competence of the economic agent is described by a hyperbolic decreasing function. The ethical competence of the economic agent does not refer to his competences (either observational or resolutory) but to his attitude.[142] When the depth of the market is small (or increases from small values near the origin of the coordinate axes in Figure 3.22), the propensity of the economic agent to resort to unorthodox (in fact, illegal) sources of information is high, because the financial market has, as yet, formed neither cycles nor patterns of functioning. At the same time, the amount of market information is low and largely irrelevant. As the depth of the financial market increases, however, the information deficit is reduced, and, in addition, resolutive competence is being formed (especially after it reaches its minimum point), which means that the economic agent feels less and less inclination/pressure to turn to those unorthodox sources of information to structure/plan his trading strategy. Of course, this curve in Figure 3.22 is a stylized one, because, depending on the beliefs, education, and even training of the economic agent in question, purely economic reasons may yield to ethical reasons, and it is possible that this curve is simply relatively flat, that is, lying close to contingent impossibility.

Figure 3.22 shows some 'forbidden' areas that should be explained:

- the area of 'necessary depth'[143] says that a market (in this case, a financial market) cannot function with a depth below this threshold. Indeed, a market is defined by a minimum volume of specific transactions, beyond which it does not exist. The quantitative threshold is, of course, more an empirical than a theoretical issue, depending on the regulatory framework of the economic system in question and even on the size (economic and physical-spatial dimension) of that system;
- the area of 'dysfunctional depth' refers to the fact that, above a certain threshold, the financi l market cannot continue to increase its depth because fina - cial flows would completely break away from the real flows in the economy, favouring the emergence of financial crises and, as a result, economic crises. More precisely, this upper threshold of market depth indicates the risk of financial crises fuelled precisely by this dissociation (with a term borrowed from psychology, *dissonance*) of financial/nominal flows from real flows in the economy;
- the areas of 'contingent impossibility' refer to the fact that, from a praxeological (and indeed anthropological) point of view, none of the three categories of competence of the economic agent can fall too close to the value'0' and cannot rise too close to the value'1'. This is a precautionary 'measure' to avoid, on the one hand, completely irrational economic agents or, on the other hand, hyper-rational economic agents, both of which are completely unrealistic.

The three curves evoked earlier, associated with the three behavioural hypotheses from the perspective of the accessible informational mix, are represented in Figure 3.22. *Nota bene*: the three competences are measured as a fraction of a unit – that is, they signify the size of the percentage of 100% that is achieved at the various points describing the depth of the market, for each of the three categories of informational competences. We note this fraction by $\gamma_{(\cdot)}$, where $(\cdot) \in \{o, r, e\}$, and where the observational aspect was noted by o, the resolutory aspect was noted by r, and the ethical aspect was noted by e.

Specific notations

- C_e^j: ethical competence of the agent j;
- C_r^j: resolutory competence of the agent j;
- C_o^j: observational competence of the agent j;
- P_i^j: informational permeability of the agent j;
- $\hat{c}_e^j$: measure of the ethical competence of the agent j;
- $\hat{c}_r^j$: measure of the resolutory competence of the agent j;
- $\hat{c}_o^j$: measure of the observational competence of the agent j;
- $\hat{p}_{ip}^j$: measure of public information permeability of agent j (*Nota bene*: this measure is of the nature of a possibility measure[144] or, more simply said, is a

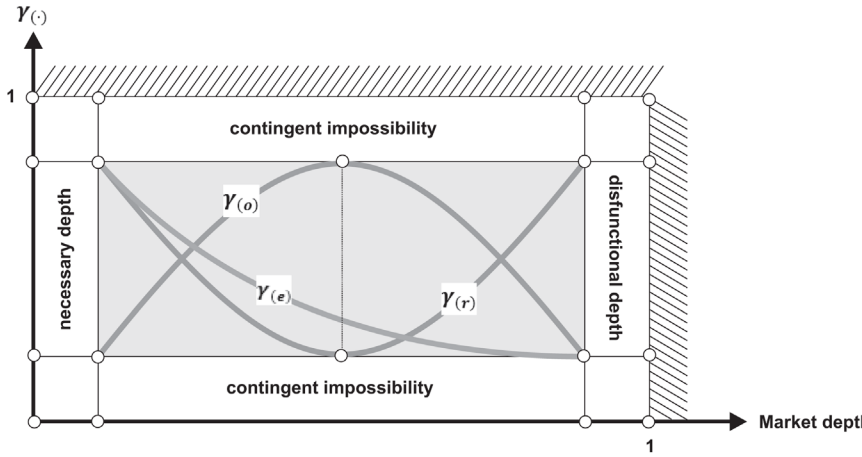

Figure 3.22 Curves $\gamma_{(\cdot)}$.

Source: Authors.

possibility), which refers to that visible information[145] to which, in principle, any economic agent has access;

- $\hat{p}_{ip}^{j}$: measure of total informational permeability of agent j (*Nota bene*: this measure refers to visible information plus private information, mostly inside information, which is acquired by incurring associated costs, often bordering on infraction – bribery, corruption, theft, deception, etc.);
- ρ_{o}^{j}: possibility (i.e., the extent of the possibility) of manifestation of the observational competence of the agent j;
- ρ_{r}^{j}: possibility[146] (more specificall , the extent of the possibility) of manifestation of the resolutory competence of the agent j;
- ρ_{e}^{j}: possibility (more specificall , the extent of the possibility) of the expression of the ethical competence of the agent j.

Quantitative relationships

- $P_{i}^{j} = \left\{C_{o}^{j}, C_{r}^{j}, C_{e}^{j}\right\}$;
- $\hat{p}_{ip}^{j} = \rho_{o}^{j} \cdot \rho_{r}^{j}$ (*Nota bene*: possibilities – or, more precisely, measures of possibility – multiply each other, provided that the events to which they are associated are independent[147] of each other, in the same way as in the case of probabilities;[148]
- $\hat{p}_{it}^{j} = \lambda \cdot \hat{p}_{ip}^{j} + (1-\lambda) \cdot \rho_{e}^{j}$, where $0 \leq \lambda \leq 1$, with $\lambda \in \mathbb{R}$.

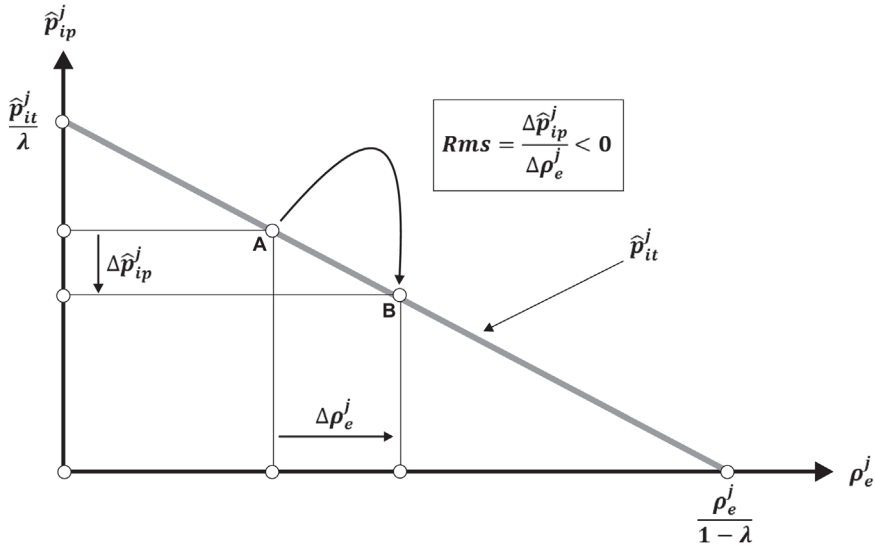

Figure 3.23 Linear combination between $\hat{p}_{ip}^{j}$ and ρ_e^j.

Source: Authors.

The linear relationship of combining $\hat{p}_{ip}^{j}$ and ρ_e^j (whose resultant is $\hat{p}_{ip}^{j}$) is represented in Figure 3.23.

- $m_a = m_d \cdot \hat{p}_{it}^{j}$, that is:

$$m_a = \left[\frac{0.11\cdot\delta_1}{\beta} + i_y - 1.32\cdot\beta\cdot(1-\beta)\cdot\delta_2\right]\cdot\left[\lambda\cdot\hat{p}_{ip}^{j} + (1-\lambda)\cdot\rho_e^j\right]$$

Also in a stylized form, for $\delta_1 = \delta_2 = 1$, $\lambda = 0.65$, $\hat{p}_{ip}^{j} = 0.8$, $\rho_e^j = 0.2$, accessible informational mix has analytical form:

$$m_a = 0.59\cdot\left[\frac{0.11}{\beta} + 1 - 1.32\cdot\beta\cdot(1-\beta)\right]$$

$$m_a = \frac{0.065}{\beta} + 0.59 - 0.78\cdot\beta\cdot(1-\beta)$$

Discussion

The objective component of the accessible informational mix must be understood in the sense of an objectified component, since everything associated with the human individual inevitably bears the mark of subjectivity (on the other hand,

however, subjectivity only exists as inter-subjectivity, and inter-subjectivity is generally considered a sui generis objectivity of Popper's third world type).

The concept of ethical competence is polemical because it is strongly idiosyncratic: what seems ethical to one individual may appear unethical to another. It is obvious that the term (and, for that matter, the concept of) *ethical* is a value-based one and therefore subject to each individual's own judgement and evaluation. In our view, ethical competence is strongly related to preference, although we are more inclined to see the two concepts as interdependent – both causally and functionally: a given preference will shape ethical competence in a specific way, and, reciprocally, a given ethical competence will adjust preference accordingly. A suggestion that might prove productive if developed analytically enough would be that, in fact, ethical competence is a component of an individual's propensity rather than a component of his preference. The main justifica ion for this suggestion is the following: values (and thus ethical value) are part of the *cultural geodesic* of every society, and cultural geodesic is another term for the concept of propensity.[149] Of course, the shift from propensity to preference (through the concept and mechanism we have called proference) also brings the ethical into preference but as a background component – somehow, from this new perspective on the location of the ethical in propensity, a causal symmetry emerges: the ethical is more causally implicated in preference than preference is in the ethical.

Although the three hypotheses on the accessible informational mix have been quite analytically examined in the right place, a few additional observations may prove useful from the perspective of the main problem of this study: equational modelling of how (and 'how much') adaptive preference integrates information in the financial market:

- it is obvious that the situational hypothesis, which in fact describes cultural geodesics, is at the fundamental level of behaviour, while the other two hypotheses – the passive hypothesis and the active hypothesis – are causally and functionally conditioned by the situational hypothesis;
- the passive hypothesis provides the database on which the active hypothesis will exercise its resolutory/cognitive competence. The name passive hypothesis is not entirely appropriate (but, for the most part, it is), because the individual/agent will observe/select from the market only that information/behaviour which is made 'visible' by the situational hypothesis – no one will observe something they don't know exists. This is why in Figure 3.24, the passive hypothesis 'enters', quite a lot, into the area of the situational hypothesis as well;
- the importance and relevance of the active hypothesis do not need any additional arguments. As we have already said, this hypothesis provides the justification for the idea put forward in this study that, in fact, in the financial market (as in any economic market, for that matter), behaviour is the generator of information and not vice versa. Although, in order to avoid irreversible dogmatism, we must also accept the possibility that information adjusts behaviour – it is behaviour which, ab initio, generates information.

The concept of informational permeability, which we propose in order to approach a more realistic *homo œconomicus*, is introduced on the basis of the concept of possibility and not on the basis of the concept of probability. We will discuss some relevant issues here.

Essentially, a probability is a possibility. The concept of possibility from a mathematical perspective is developed within concerns about a theory of possibility, analogous to probability theory – a review of contributions to the subject of possibility theory can be found in Dubois and Prade (2011).[150] When constructing a distribution of hypostases in which an event will (or is likely to) occur, each such hypostasis is associated with a number that is called a probability, but, in fact, this number is a possibility:

- the main confusion between probability and possibility comes from the fact that, following probability theory (and especially under the influence of Kolmogorov's theory of probability), probability is always associated with a positive, sub-unit number (in a closed real interval). In this context, most researchers consider that possibility is a philosophical concept which, when it acquires a numerical value, becomes, *eo ipso*, probability, that is, an empirical concept;
- in fact, in our opinion, we are simply dealing here with a terminological redundancy: there are only possibilities which, when imagined and associated with numbers, are (unnecessarily) called probabilities. Therefore, when an event actually occurs (i.e., in terms of quantum mechanics, when the event in question collapses into one of the hypostases described ex ante in the distribution of events – usually in the form of a random vector), it can take only two of the acceptable values from that distribution: either'0': the hypostasis has not occurred, or'1': the hypostasis has occurred. It follows, therefore, that the correct term[151] for predicting the hypothetical future event is *possibility*, not *probability*;
- here the following objection might arise from the 'fundamentalist' followers of the concept of probability: at least in the case of (objective) frequential probability, the records we have of the occurrences of the hypostases of an event describable by 'probability' distributions can sufficientl assure us that we are not dealing with mere possibilities but with possibilities already experienced – and we might well call the number associated with a possibility repeatedly experienced in the past by the term *probability*. We answer such an objection in advance in the following way:
    - even if a certain frequency of occurrence of a hypostasis of an event in the past is relatively high, this only means that we can have greater confidence in the occurrence of that hypostasis (and associate a higher positive and sub-unit number with it than with other hypostases that have not been shown archivally to be as frequent), but the hypostasis itself is still a possibility;
    - updating of a possibility has nothing to do with repeating that update;[152]

  - similar to Popper's caution that repeated corroboration of a conjecture/hypothesis does not increase the probability of that conjecture/hypothesis being true in the empirical sense, the repeated occurrence of a hypostasis of an event considered stochastic (but not random) does not entitle us to make the conceptual shift from possibility to probability.

- the use of the term (and concept of) *possibility* gives an additional right of 'citizenship' to the term *subjective probability* (*Nota bene*: obviously, we would like to use the term *subjective possibility*!), including the best known such subjective probability, namely, Bayes-type probability. Indeed, the individual (idiosyncratic, by definition) will associate 'probability' numbers to the hypostases of an event on which, in the initial state (i.e., in the state in which the *a priori* probability distribution is formed), he has no information (or has basic information, susceptible to be adjusted later). However, in this situation, it cannot be a question of probability but, obviously, of possibility;
- another argument concerns the singular event case.[153] In this case, there are neither archives of objective frequential probabilities nor preferences formed over time for assigning subjective (Bayesian) probabilities. It is obvious that, in this case, we can only have a (subjective) estimate of the possibilities of occurrence of the hypostases of the event under consideration. Since in economics (more generally, in society) we have only singular events, it follows peremptorily that it is more relevant and more accurate to talk about possibilities than about probabilities (which is what we did when we formalized informational permeability).

The weights (theoretical,[154] so far) with which the different competences (observational, resolutory, ethical) enter the agent's decision/behaviour as a function of (financial) market depth are, in our view, of greatest importance in quantitatively modelling the relationship between adaptive preference and information, but the main considerations in this matter will be developed further.

The hypothesis of the linearity of the formation of total permeability from the public permeability and ethical permeability is obviously only a hypothesis/conjecture to be tested empirically.[155] Here, however, there is in fact a double linearity: (a) the linearity of the formation of total informational permeability; (b) the linearity (reduced to the sum of'1') of the formation of possibilities (more precisely, measures of possibility) concerning, on the one hand, public permeability and, on the other hand, ethical permeability (the latter, as we have shown, being a private permeability). If the value of λ, which provides linearity (a), is to be inferred empirically, linearity (b) should, we believe, (also) have a theoretical foundation.

At this point in the study, we do not develop this idea further, but we 'venture' to make a conjecture that can be tested empirically. The statement of the conjecture is as follows: *the ratio between the measure of possible ethical permeability and the measure of possible public permeability is directly*

proportional to the depth of the financial market, although the proportionality factor is exclusively empirical and will have to be calculated by statistical-mathematical means.

Conclusion

The accessible informational mix is a component part of the available informational mix, that is, the part which, at a reasonable cost and, above all, at a cost which the market 'appears' to be able to reward with an appropriate return on the financial securities traded, is likely to be accessed by the economic agent concerned. In the case of the accessible informational mix, two additional competences emerge (in addition to the observational competence identified in the case of the available informational mix): resolutory competence and ethical competence. Information should be seen as subsequent to behaviour and causally and functionally dependent on the latter. The depth of the financi l market has an important and relevant impact on the agent's competence, as well as on the agent's decision and behaviour in the financial market, and the categories of information and market depth are, in terms of their accessibility by the agent, in a link that should not be ignored.

Accessed informational mix

Both the available and accessible informational mixes are generated by the economic and social environments, in particular, the financial market. Of course, the available informational mix has a predominantly objective character, while the accessible informational mix combines objectivity with subjectivity, especially in terms of resolutory and ethical competence. The accessed informational mix is what is actually used from the accessible informational mix. The general relationships between the three informational mixes under discussion are represented in Figure 3.24.

Since the accessed informational mix is conditioned by preference (in our case, of course, by the adaptive preference), which in turn, as shown earlier in this chapter, is conditioned by agent propensity which in turn is an effect of the cultural geodesics of the society (or economic system) in question, we will postpone discussion of this mix until after examining these conditionalities.

Propensity and adaptive preference on the financial market

CONCEPTUAL ASPECTS

The propensity of the economic agent is a tendency/inclination to action/behaviour. As it has already emerged from what has been discussed earlier, we consider that there is a logical (and chronological) primacy of behaviour over information (Dinga, 2021), in the sense that it is not information that underlies behaviour but

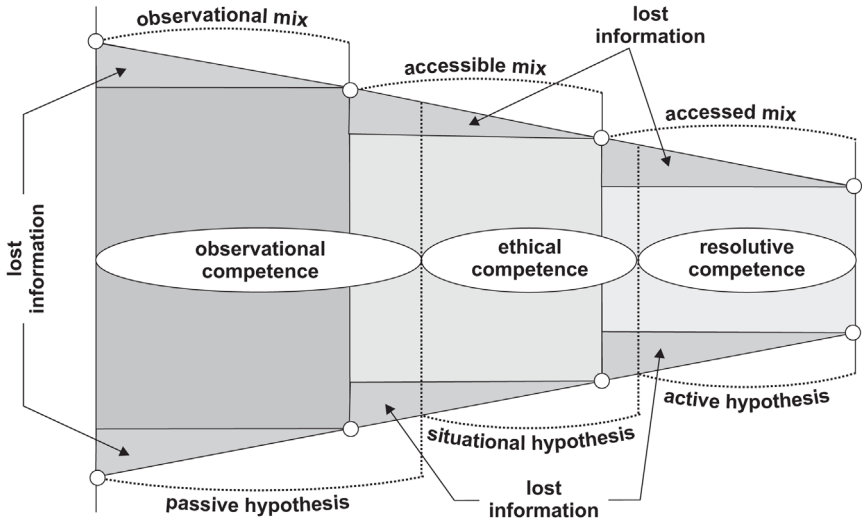

Figure 3.24 Informational mix, behavioural hypothesis, and agents' skills.
Source: Authors.

exactly the opposite (of course, without neglecting a certain circular causality between the two entities). We will take up some of the concepts already evoked in order to put them in the qualitative and (where possible and relevant) quantitative relation proper to the logic of financial market functioning.

CULTURAL GEODESIC AND PROPENSITY

Cultural geodesic is the indispensable background of all social behaviour and therefore also of economic behaviour with its species: financial behaviour. The term *geodesic* is used, of course, with the declared aim of suggesting a certain capacity to attract behaviour[156] around or close to this geodesic, which is considered to integrate all positive norms (formal and informal) as well as non-positive norms (e.g., norms resulting from religious conceptions[157]). The concept of the maximum (referential) extension of geodesic is that of a *situational framework* which generates a number of sectoral geodesics as follows: economic geodesic (which 'governs' economic behaviour), political geodesic (which 'governs' political behaviour), and so forth.[158]

Propensity (from now on, P) cannot manifest itself outside the situational framework (from now on, SF); it is a product of this SF (which, of course, through

Table 3.1 Substantial aspect of the relationship between SF, CG, and P.

SF		*CG*	*P*			
			on taking action		*on taking the risk*	
			initiative	*reticence*	*assumption*	*avoidance*
Democratic society	centralized economy	conformist	middle	middle	middle	middle
		opportunist	middle	low	middle	low
	free economy	opportunist	high	low	high	low
Dictatorial society	centralized economy	conformist	low	high	low	high
	free economy	conformist	middle	low	low	high
		escapist[159]	middle	middle	high	middle

Source: Authors.

feedback, can, in turn, influence SF, in a more or less significant way). Thus, in order to identify, or at least to intuit propensity, SF is the first clue – for example, in a centralized economy, where the government assumes not only economic ownership but also strategic economic decision, it can be 'anticipated' that private initiative will be rather poorly represented in individual propensity, which will instead be dominated, by paternalism, and of course exactly the opposite will be the 'anticipation' of propensity in a democratic society, where market freedom dominates.

If, from a qualitative point of view, the link between SF (i.e., the sectoral cultural geodesic generated by that SF) and propensity is quite unproblematic, the quantitative link between them is much more difficul to establish. Therefore, at this point of the discussion, we will introduce a (purely indicative) grid that could be valid for the 'classes' of propensities that a given SF, that is, a given cultural geodesic can generally underpin (Table 3.1) – with CG we will note, in the following, the cultural geodesic.

PROPENSITY AND ADAPTIVE PREFERENCE

As we have shown earlier, propensity is somehow the cause of preference which, in turn, is a cause of behaviour which, in turn, is a cause of information and so on. But what kind of causes are we talking about in this causal mechanism that starts from the situational framework and goes all the way to the production of information in the financial market? A synoptic diagram (Figure 3.25) can provide a possible answer (with AP is noted the adaptive preference).

Quantitatively, we are only interested in the causal connections between propensity and preference. We will make some preliminary considerations.

As is generally recognized in the specialty literature, propensity has two irreducible features: (1) it is objective, and (2) it is associated with the singular event. The objective character (more precisely, it is, of course, an objectivity that arises

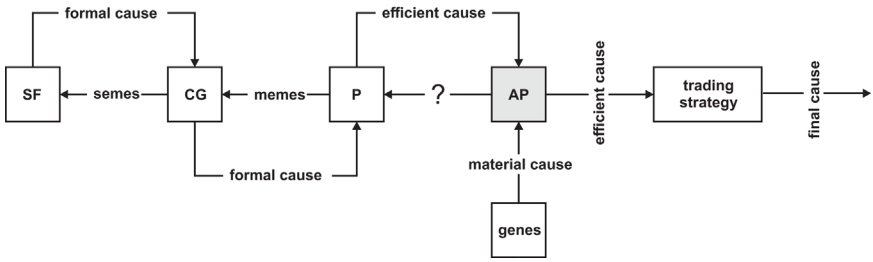

Figure 3.25 Causal relationships generating adaptive preference.

Source: Authors.

as a result of the objectification of inter-subjectivity, discussed earlier) results from the fact that, formally speaking (see Figure 3.5), propensity is generated by cultural geodesic – an objective entity – which, in turn, is generated by the situational framework – also an objective entity. The objectivity feature of a subject property is, of course, problematic and requires at least the following two additional clarifications:

- *firstly*, the objective character results from the fact that both CG and SF are externally opposable to any subject/individual/agent. In other words, neither SF nor CG are emanations or effects of the subject/individual in question – in fact, the individual is born and formed, at the level of memes and semes, by these two objective entities in this first sense;
- *secondly*, the objective character results from the fact that in both SF and CG, several individuals enter, not just one. The idea that several individuals, mostly autonomous from one another, would emanate exactly the same propensity should be associated with infinitesimal probability[160] (cases of collective hypnosis are excluded, as they are neither permanent nor general).

The associability of propensity with the case of the singular (unrepeatable) event is contained, as a predicate, in the very definition of propensity. Both Popper and his supporters (also, with some nuance, most of his critics) agree that propensity must be associated (and only makes sense in association) with the singular event, be it economic, political, or otherwise.[161]

From the perspective of financial market functioning, propensity has the following basic predicates:

- it is the main filter for the informational permeability of the agent. Indeed, it is known that the individual only observes what he already 'knows' to exist,[162] and therefore, the agent's informational permeability will be a function of his propensity;

- it is the objective anchor to which the agent's subjective preference is fixed. As we have shown earlier, propensity is an efficien cause of preference;[163] as a result, we can specify the following:
    - propensity can be the 'host' of a set of preferences that the agent holds. Standard economic theory has long accepted the idea that the agent has (can have) a set of preferences for economic behaviour, preferences that are lexicographically ordered.[164] This ordered set of preferences is claimed to be of the same propensity;
    - propensity is therefore an efficien cause of preference, in the sense that no preference of an agent, from its own set of preferences, can be incompatible (or inconsistent) with the generating propensity. Moreover, we cannot accept that an economic agent has more than one propensity. In this sense, from an economic point of view, an agent's propensity is its behavioural fingerprint, unique and distinct from any other propensities of other agents participating in the financial market;
    - the question of ordering preferences within the agent's preference set obviously arises. This is an intensely disputed issue in the literature and is not the subject of the present research. In any case, the ordering is completely idiosyncratic and is opaque to the observer until the moment the agent makes the decision and, in fact, until the moment it executes the action dictated by that.

How to switch from propensity to preference can be described (qualitatively), as follows.

Propensity is a condition for the emergence and functioning of preference. In this sense, propensity knowledge (which is – or should be – a distinct branch of economic research) functions as a genus-type predictor for preference, while preference knowledge functions as a species-type predictor for the trading strategy that will ultimately be accessed by the agent in question (see the suggestions in Figure 3.25).

Propensity functions as a filter for selecting the agent's preference set. In fact, preference is the result of the successive action of three qualitative filters:

- *primary filter*: refers to the SF: an agent will only be able to form a pattern of behaviour in the SF in which it is physically and culturally immersed;
- *secondary filter*: refers to the CG: an agent in a given SF will only be able to form a behavioural model within the CG in which it is immersed – for example, in one way an agent immersed in a reflexive CG, such as a phenomenological philosopher, behaves (within the financial market), and in another way, an agent immersed in a pragmatic CG, such as a stock trader, behaves;
- *tertiary filter*: it refers to P: an agent in a given CG will form its own P, depending on the particulars of its immersion in society – the social class to which it belongs, the type and level of education received, the micro-social group in which it lives, and so forth. It is obvious that, in the case of any of

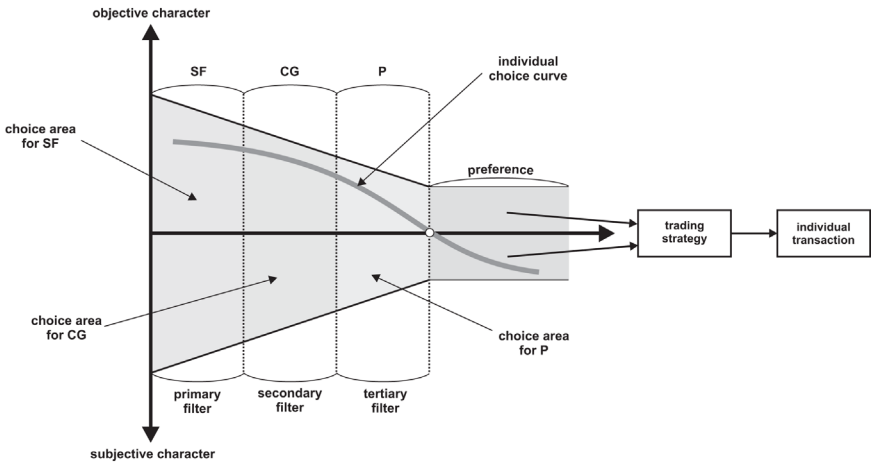

Figure 3.26 Cultural filters and the logic of adaptive preference formation.
Source: Authors.

the three filters mentioned, objectivity is present although with decreasing intensity, as we 'advance' from SF to P. Figure 3.26 attempts to clarify, qualitatively, this finding.

Thus, the three filters, as they are applied (naturally, not institutionally) from SF to preference, at the same time narrow the scope/field of choice for the agent (also highlighted in terms of the relationship between agent behaviour assumptions and informational mix categories). Consequently, the individual choice curve is a decreasing and concave curve with respect to the objective nature of choice, and which registers an inflection point (namely, point of change from concavity to convexity) at the 'moment' of the shift from propensity to (adaptive) preference. Next, once the adaptive preference is formed, that is, once the agent enters the space of subjectivity of choice, he decides on the trading strategy and, further, on the individual transaction(s), he will operationalize in the financial market.

Quantitatively, for the existence of a curve with an inflection point, the 'closest' analytical form is a polynomial equation of third degree: $a+bx+cx^2+dx^3$, with $a,b,c,d \in \mathbb{R}$ and obviously $d \neq 0$, for which the inflection point is given by the solution of the equation: $2c+6dx=0$, that is, it occurs at the point $x=-\frac{c}{3d}$.

ADAPTIVE PREFERENCE AND INFORMATION

The question arises as to the category (or categories) of information (not the category of informational mix) with which adaptive preference is 'confronted'. We will make the following considerations in this matter.

Adaptive preference deals with all three categories of information (formal, implicit, and bound), of course in specific modalities, intensities, and effects

On formal information (i_x):

- this category of information has the greatest impact on the variation of adaptive preference because, as shown earlier, formal information is located in the SF core, from where the whole logical and generative mechanism of adaptive preference originates;
- formal information is the category of information least sensitive to feedback from adaptive preference because it is mostly generated by general societal considerations, only part of which relates to the economy and only part of which relates to the functioning of the financial market. As a result, relatively speaking, formal information can be considered as an autonomous category of information in relation to adaptive preference;
- we therefore perceive an asymmetry in the relationship between formal information and adaptive preference: while the direction formal information-preference act is maximal, the direction adaptive preference-formal information reaction is minimal;
- the way of adaptive preference adaptation, relative to formal information, is direct and immediate.[165] In our view, when we talk about adaptive preference, we must first of all refer to its adaptation from the perspective of formal information;
- an important feature of formal information should be mentioned: it is the most stable category of information, and the experts' recommendations suggest that this category of information should be extremely conservative, precisely to allow the business environment to design its long-term business plans;
- at the same time, the shock created by the change in this category of information is maximum comparative to the shocks caused by changing of the other two categories of information;
- the competence involved by the adapting preference to formal information is observational competence, particularly since the significance and impact of this information are, in most cases, contained in the very operative part of the rule in question;[166]
- adaptation of the preference to formal information is a semantic adaptation;
- adapting preference to variation in formal information involves a discussion of the type of change in formal information:
    - if the change is a contractive change – that is, reducing the scope of business opportunities, for example, by prohibiting certain categories of transactions – then the probability that the economic agent will change/adapt its preference is higher, whereas in the case of relaxive type changes, the probability of change/adaptation is comparatively lower;
    - even in the case of a contractual change of the formal information, the agent may choose not to change his preference, assuming, as we said, the costs of voluntary non-compliance with this change of the formal information;

- in the case in which the change in formal information has neither contractive nor relaxed meanings, then the change in preference is independent of the change of the information, although the change of the preference may still occur in this case either by coincidence or by causal error;[167]
- *in principle*, in the case of formal information, the available informational mix equals the accessible informational mix and equals the accessed informational mix, that is:

$$m_d \equiv m_a \equiv m_u$$

We say *in principle*, because the free will of the agent can make the accessed informational mix, in some cases, smaller (as a sphere) than the accessible informational mix;

- formal information subsumes cybernetic systems by order 1 – the observing subject is not (principally) in the observed system, because formal information is positioned outside of the agent which is acting on the financial market.

On implicit information (i_y):

- as stated earlier, implicit information is the information 'produced' by the economic agent itself, by interpreting 'financial market behaviour', in fact, by interpreting the behaviour of player agents on the financial market;
- adjusting preference on the basis of implicit information requires the use of the agent's resolutory competence – a cognitive competence that derives both from the agent's training in financial market functioning and from previous experience of playing in the market;
- in addition to its own conclusions, based on its own resolutory competence, and extracted (derived, inferred) from observing (and participating in) economic game in the financial market, the agent can also 'produce' implicit information through its memetic sensitivity – by observing changes in the behaviour of other economic agents, the agent in question may decide to imitate that behaviour, based on the presumption that the agents who change their behaviour are agents with sufficien resolutory competence themselves. This effect – sometimes called the herd effec [168] – is quite common, especially if the agents in question do not have sufficien resolutory competence or confidence in their own behaviour patterns [169]
- after formal information, implicit information has the greatest power (capacity, potential) to modify/adapt preference. This time, however, it is a non-operative adaptation, and it is a facultative one – the economic agent can 'refuse' to adapt his preference, assuming the consequences, usually of the nature of (decreasing) the profit or return obtained from the choice of trading/commercial strategy on the financial market;
- in the case of implicit information, the accessible informational mix is at most equal to the available informational mix, and the accessed informational mix is at most equal to the accessible informational mix, that is:

$$m_d \leq m_a \leq m_u$$

- adaptation of preference to implicit information is indirect and mediated. The indirect character consists in the fact that the agent has to make an interpretation of the behaviour/behaviours on the financial market, using its own resolutory competence,[170] so as to form the information that could eventually lead to a change of the preference. The mediated character is that the same 'stock' of financial market behaviour can lead, to different agents, with different resolutory (and hermeneutic) competences, to different acquisitions (quantitative and qualitative) of the implicit information;
- in the case of implicit information, the financial market looks (and functions) different for different economic agents, due to differences in their resolutory (and hermeneutic) competence. At the same time, the preference itself, held by the agent, may obscure or, conversely, illuminate some behaviours, along with their meaning. In this sense, one can speak of an 'intelligence' of the preference,[171] which could be, succinctly, described as follows:
    - an agent's preference generates a 'bright cone'[172] that is uniquely observed (and therefore 'translated') by the agent. Outside this 'bright cone', the behaviour of other individuals, and hence the behaviour of the financial market, is unobservable;
    - implicit information subsumes cybernetic systems by order 2, because the observer subject is inside the observed system, that is, inside the financial market;
    - as there are different preferences of different agents, there will also be different 'bright cones' on the financial market, so the implicit information will differ greatly between agents [173]
- implicit information is the most unstable category of information; its volatility is very high because it depends on myriad individual, idiosyncratic decisions made on a subjective basis (since preference is, par excellence, a subjective characteristic).

On bound information (i_z):

- bound information is the least autonomous of all three categories of information.[174] In the limit, the bound information can be said to be a function of the other two categories of information: $i_z = i_z\left(i_x, i_y\right)$, having the following qualitative mathematical characteristics:
    - the higher (quantitatively) the contractive component of formal information, the more the bound information is accessed (and vice versa, if the relaxive component dominates in formal information);
    - the higher (quantitatively) the implicit information, the lower the bound information (and vice versa);
    - so if we rewrite: $i_z = i_z\left(i_x^c, i_x^r, i_y\right)$, where the contractive formal information (see the meaning of this type of information earlier) was noted by i_x^c

and the relaxive formal information was noted by i_x^r, then we have the formal conditions:

$$\frac{\partial i_z}{\partial i_x^c} > 0$$

$$\frac{\partial i_z}{\partial i_x^r} < 0$$

$$\frac{\partial i_z}{\partial i_y} < 0$$

- the bound information is produced neither by the normative authority nor by the market. In a sense, bound information is produced, like implicit information, by the agent itself but 'pressed' by the actual combination of formal and implicit information;
- of course, as mentioned earlier, accessing bound information depends on cultural geodesics (which has already entered the agent's preference formation);
- in addition, the bound information is accessed according to the ethical competence of the agent: its values (partly included[175] in the preference) will 'dictate' whether the agent in question accesses the bound information or not, through different routes (briber , corruption theft, etc.);
- bound information subsumes an intersection between cybernetic systems by order 1 and order 2, because the observing subject is both inside and outside the observed system;
- although the dominant one, in accessing bound information, is ethical competence (as mentioned earlier), perhaps this category of information is a result of the combination of all three types of competence available to the agent.

THRESHOLDS AND PREFERENCE ADAPTATION THROUGH INFORMATION INTEGRATION

Thresholds are one of the key concepts of any kinematics (or dynamics, as the case may be). They are present not only in economic phenomenology but also in any phenomenology[176] – including the most refined philosophical method of inquiry: dialectics. Essentially, a threshold is a limit (to which it is sometimes possible to attach a numerical value) of accumulation (usually quantitative) of a phenomenon, a limit at which a sudden and often significant change (usually qualitative) occurs. In fact, the best-known threshold in economic phenomenology is even called the threshold of significance: it is the threshold at which the economic agent updates a decision – takes a decision, abandons a decision already taken, or adjusts a decision taken or about to be taken. In economics, where subjectivity is objectified by the interplay between subjectivities, thresholds cannot be ignored, under sanction of the unrealism of the economic theories or models developed. Obviously, thresholds imply inertia (dead zones) or eruptions, in terms of both decisions and, more importantly, behaviours.

Inertia is specific to so-called moments describing the kinematics of economic variables (e.g., the price of a particular financial security), while eruptions describe so-called exuberances: accelerations, not always rational, of trading actions for various reasons. Specificall , to the 'left' of the thresholds, we usually have inertia, and to the 'right' of the thresholds, we usually have eruptions.

The existence and functioning of thresholds are one of the strong arguments on the basis of which some analysts insist on a quantum modelling of economic phenomenology (along with perhaps the strongest argument that both economic decisions and actions occur discretely).[177]

In this study, thresholds are present (and embedded) in the changing praxeological characteristics of economic agents – at the level of competence, of information category, or of informational mix operated – when (financial) market depth reaches certain thresholds.

Preliminary hypotheses

In the formalization associated with the (actually) accessed informational mix, we take into account the following behavioural assumptions, which we 'decree':[178]

- ($C1$) the causal relationship $P-AP$ (propensity − adaptive preference) is asymmetric, that is, functioning only for $(P)\overrightarrow{cauzally}(AP)$, not the inverse relationship: $(P)\overleftarrow{cauzally}(AP)$;
- ($C2$) preference is (can be) affected and therefore can change/adjust/adapt under the impact of any informational mix (available, accessible, accessed).[179] It is true that, under the impact of the available informational mix, respectively, of the accessible informational mix, adaptive preference manifests itself through abstention – but consequently undergoes adjustments – whereas, under the impact of the (actually) accessed informational mix, adaptive preference manifests itself through act:
  - ($C2.1$) how adaptive preference adjusts/modifies/adapts through abstention can be described as follows: the available informational mix and, similarly, the accessible informational mix generate the agent's anticipations[180] about potential opportunities, which could be addressed (more precisely, about the choice of the appropriate trading strategy for those informational mixes), although the act itself (the operation of the individual transaction) does not occur. We are dealing here with passive learning which, based on the agent's confidence in its own evaluation,[181] can modify the preference;
  - ($C2.2$) how adaptive preference adjusts/modifies/adapts itself under the impact of the accessed informational mix generates the agent's post-assumptions about actual opportunities that have already been operated by the choice of trading strategy (i.e., individual transaction) and that have yielded results. Depending on the 'sign' of the financial outcome

(plus: for profit; minus: for loss), the agent will adjust/modify/adapt his preference. This time we are dealing with active learning, generated by the actual experiencing of the preference;

- ($C3$) lags (or leads, as the case may be) are considered to be embedded in the 'physiology' of adaptive preference, as are thresholds (both floor and ceiling). In fact, adaptation (and, more generally, adaptability) also depends directly on these ingredients: lag, lead, and threshold. From an operational point of view, these three characteristics of adaptive preference represent the content of a black box and are always revealed ex post, either in relation to the act or in relation to abstention. This is a real difficult in quantitative modelling of adaptive preference objectification, as its obturation is a significant part of the efficien causality of the agent's behaviour, but for the moment, we will accept this hypothesis/conjecture.

Auxiliary discussion

Although earlier we have discussed, in general, the relationship between propensity and preference, it is time to decide, from the point of view of the researcher's choice, on the logical relationship between the two concepts which will be effe - tively assumed in the following. The question of the relationship between propensity and preference (or adaptive preference) is intensely polemical and is, in our opinion, a conjecture in itself,[182] which we will have to take up. We believe that this potential conjecture has two 'faces': (a) propensity is the cause of the cause (the second cause being, obviously, adaptive preference); and (b) propensity is equivalent to adaptive preference, being another term for the same concept. We will briefly consider each perspective.

PROPENSITY: CAUSE OF ADAPTIVE PREFERENCE

This perspective is in line with both the suggestion provided in Figure 3.25 and the conjecture (C1) on the asymmetry of the causal propensity-adaptive preference relationship.

Perspective allows the conceptual and operational separation between propensity, which is kept strictly in the objective domain, and adaptive preference, which is kept strictly in the subjective domain.

The crisp distinction between propensity and adaptive preference has some theoretical advantages, including:

- it provides greater conservative (continuity) propensity;
- by providing this conservative capacity, propensity is given an important predictive role – indeed, providing conservability of propensity (between very wide thresholds) is likely to indicate a probable economic behaviour of the agent; in this way, propensity becomes a predictor of economic behaviour (specificall , financial or financial market behaviour)

- operationally, this perspective points to a way of identifying preference ex ante (thus avoiding black box behaviourism) according to the principle (paraphrased from the famous *cherchez la femme*): *cherchez la propension*.

The main difficult in this perspective relates to the 'condition' that the preference (once adjusted/modified/adapted in the course of its objectification through financial market trading operations) cannot in turn, through feedback, modify the propensity:

- of course, the rigidity of propensity is in line (logically, i.e., of the nature of consistency) with its objective character (if we are to keep within the parameters proposed by Popper); therefore, the invariance of propensity has a certain justification;
- however, from a conceptual point of view, it seems that, with this perspective, we are only taking the criticizable (and much criticized) 'axiom' of the neoclassical economic model (transposed into the *homo œconomicus* model or, more applied, into the EMH) on the invariance of preference, that is, of the set of preferences (including their lexicographic ordering) at the level of the economic agent, one step further: therefore, it is not preference that is invariant but propensity;
- it is true, at the same time, that shifting the conjectural invariance from preference to propensity leaves room for some variability in preference (which is in line with the empirical findings of behaviourism, cognitive psychology, and neuroscience) and, moreover (and very importantly), leaves room for the 'immersion' of (adaptive) preference in the subjective zone.

From a formal point of view, we will obviously have to find/construct the quantitative operator[183] (denoted Ω earlier) that generates a 'list' of adaptive preferences, all consistent with the propensity in question.

The idea that propensity is invariant, while allowing for the subjectivation of preference (which allows for the very existence of a lexicographically ordered set of preferences of an agent 'endowed' with a given propensity), remains, however, problematic. Perhaps one solution would be for the propensity (considered, hereafter, as having an objective character) to remain invariant only within a tunnel of acceptable variation of the preference (or adaptive preferences) generated by it. And here, the difficul question that arises is whether this tunnel (or these tunnels)[184] can be conditioned (i.e., how, including quantitatively/formally) by the adjustment/modification/adaptation of the preference.

PROPENSITY: ALTER EGO OF ADAPTIVE PREFERENCE

This perspective 'cuts' the Gordian knot of the (causal) relationship between propensity and adaptive preference precisely by eliminating this relationship, which obviously implies the coincidence of the terms *propensity* and *adaptive preference* over the same concept – our suggestion is that this concept obtained by the

operation of semantic overlapping between propensity and preference should be called *proference*, as discussed earlier. If we consider this perspective, the following consequences must necessarily be assumed:

- an economic agent's preference is, in fact, its propensity;
- the objective character of propensity (demanded by both Popper and many other analysts) must be abandoned (or at least strongly relaxed), because preference must be subjective either absolutely or relatively.[185] Objectivity of propensity will have to be replaced by some elasticity of preference (see Chapter 1). More precisely, we propose that preference should have the degree (and nature) of objectivity that we accept (by virtue of their belonging to Popper's third world) for the SF and the CG, respectively;
- replacing the objective character of propensity (which is now equivalent to preference) with the objectified character of preference seems to us an acceptable and natural solution, based on all the previous discussions in this volume on propensity, preference, and, above all, the specificity of the economic/social domain in relation to the natural domain;
- from a logical point of view, propensity is replaced, so to speak, by the SF-CG mechanism, which has no objective character but an objectified one;
- this ensures, on the one hand, the avoidance of the total subjectivism of preference and, on the other hand, the avoidance of the total objectivism of the 'new propensity': the SF-CG pair, which, we repeat, we'll call it, from now on, proference;
- thus, the change of proference is possible from two directions (not always convergent and not always consistent with each other): (a) the SF-CG objectified component; and (b) the idiosyncratic component – which is usually now called preference. The result of these movements of the two components constitutes the content of our concept of adaptive preference;
- so, if we denote with O (from objectified status): the SF-CG component, with S (from subjective status): the preference, and with p the proference, then logically it can be written:

  $$p = O \wedge S;$$

- the advantages of this perspective are important, both from a theoretical point of view and (especially) from a methodological and instrumental perspective:
  - we have no longer a supposedly objective and, above all, supposedly immutable propensity that nevertheless causes a non-invariant preference;
  - there is no need to explain how an objective propensity can generate a subjective preference;
  - it recovers the contained idea, more or less clearly, in the positions taken on the issue of propensity, according to which the probability generated by objective propensity should be subjective. If we equate the probability caused by propensity with preference, then this idea remains valid, *mutatis mutandis*;

- we no longer need to explain how it is possible for propensity (which is not a probability but a property, presumed even objective, and therefore not associated with a number) to cause a probability (whether subjective or not) that is necessarily a number – the subjective preference generated within the proference need no longer be a number but an individual, idiosyncratic particularization of the objectified SF-CG pai .

OUR OPTION

Further analysis involves, of course, choosing between perspective (a) and perspective (b). Based on the advantages briefly inventoried earlier, our choice is perspective (b), and, in the following, our approaches and research efforts aimed at the rest of the objectives we have undertaken will be subsumed under this hypothesis/conjecture (in fact, we shall develop the Autopoietic Market Hypothesis – APMH, which will be presented in volume 2 of the research).

Suggestions for future research topics

Based on the presentation in this chapter, we consider that scientific subjects in three research lines are potential for development:

I. In the field of financial market

- the normative framework as propensity in financial behaviour;
- co-evolution of two symbolic species: preference and financial behaviour;
- information efficiency versus behavioural efficiency in the financial mar
- implicit information and financial market behaviour;
- the factual testability of EMH – logical considerations.

II. In the field of mathematics applied on the financial market

- propensity and probability in shaping economic preference;
- economic preference – medium term between propensity and probability;
- negative probabilities and aversions on the financial market;
- reverse Bayesian propensity and probability on the financial market;
- proference field on the financial market
- relative preference versus conditional preference in the financial market;
- Bayes probability and causality in the financial market;
- Gödel-ian theorems and *homo œconomicus* model.

III. In the field of economic theory

- cultural geodesic as a propensity in economic behaviour;
- symbolic utility and behavioural economic decision;
- retroversion of the representative agent to the individual agent;
- adaptive preference and the problem of inter-individual commensurability of preferences.

Notes

1 The term *equation* means, etymologically, equality, which does not imply, *eo ipso*, quantitativism (see, e.g., the equations, in this broad sense, presented by Nicholas Georgescu-Roegen in his fundamental work *The Law of Entropy and the Economic Process*, Expert Publishing, 1996).
2 Recall that adaptive preference – the concept and the term – was examined in Chapter 1.
3 Obviously, the two previous studies mentioned do not, strictly speaking, provide a theory (understood as a coherent set of principles and causal description theses of the ontology, epistemology, and praxeology of a given field), but we consider it to be a good theoretical starting point.
4 By objective non-frequential probabilities, we mean objective probabilities assignable to the singular case (event) as, in our view, presents itself the experience (direct or indirect) of the functioning of financial market.
5 As is well known, Toma d'Aquino is an Aristotelian, including regarding Aristotle's physics.
6 The reference to the modern concept of preference is more than obvious here. By inclination Toma d'Aquino means *stable expectations* about actions, or, in the terminology we will use later, propensity (i.e., by objectification, preference) 'signals' (here in the precise sense of Robert Nozick, *The Nature of Rationality*, Princeton University Press, 1993, given the role as predictor of principles assumed and declared by a public commitment) for behaviour (i.e., the choice of trading strategy). It is important to point out that the application of the concept of propensity in the social field (economics, sociology), as well as in the humanistic field (psychology, anthropology), is along Thomistic lines, because, unlike Peirce, Toma d'Aquino accepts both the efficien cause and the final cause (purpose), the latter being specific to man, as being capable of teleological representations. Thus, according to this thinker, there are six stages in the realization of an action (Stump, 2005): the first act: the intellect determines that an end is good under certain circumstances (i.e., under Popper's or Fetzer's conditions – our emphasis); the second act: establishing that the goal can be achieved, in those circumstances (e.g., by certain means); the third act: choice of means to achieve the goal; fourth act: determining the appropriateness of the means to achieve the end; fifth act: command (imperative of the intellect); sixth act: action (i.e., performing the action, as a praxeological act – our emphasis). If we interpret Thomistic theory from a modern perspective (Kantola, 1995), it follows that Toma d'Aquino can be placed in the category of thinkers who followed the frequential (objective) theory of probability.
7 Some authors believe that the quantum world is the only case of pure indeterminism in nature. The rest of the cases where we have incompleteness of knowledge do not fall under indeterminism but, with a relatively rebarbative syntax, under statistical determinism, shaped by stochastic distributions of events.
8 The singular case is also specific to economics (social in general), which is why the concept of propensity is very useful in modelling (either logically or quantitatively) economic phenomena.
9 The frequential probability is a probability measure (in the Kolmogorov sense, i.e., based on set theory) that is the limit of the frequencies of an infinite sequence of repetitions of an experiment. Obviously, since an infinite sequence of repetitions is not actually (but only potentially) possible, it follows that there is never in fact an exact frequential probability but only an approximate one (i.e., approximated to the finite sequence of repetitions). Thus, even from the perspective of frequential probability, there is a need for an examination of the event *per se*, without recourse to the sequence of repeated experiments. As we shall see, propensity theory (or propensive theory of probability) aspires to exactly this.
10 Popper wanted, in fact, to find an explanatory model for the phenomena of interference and of superposition in quantum phenomenology.
11 In the quantum world, this is expressed by the so-called transition probability, obtained by the scalar product of the functions describing the two states, normalized (orthonormal) functions in a (same) Hilbert space (Johansson, 2009).

12 Economic theory (at both the micro and macro levels) uses the concept of *propensity* but in a much simpler sense – as a marginal numerical value that causally expresses the variation of one economic variable relative to another economic variable – for example, in microeconomics: the marginal propensity to consume: $c = C'_V$, where c is the marginal propensity to consume, C is the Keynesian consumption (or consumption function) $C = a + c \cdot V$, and V is current income (C'_V is the partial derivative of the consumption function with respect to current income); in macroeconomics: the marginal propensity to import, similarly calculated as the partial derivative of the import function in relation to national income. Thus, the concept of inclination/propensity now commonly used in economic theory has no probabilistic connotation but is just a (not very appropriate) name for a marginal calculation.

13 Popper called this relativization as being in the nature of dispositional conditions. We shall advance, for the case of economics, the concept (syntagm) of *situational framework* or *ecogeodesic*. The departure from Popper's concept is that ecogeodesic will include the normative framework, on the one hand, and the habitus (here not in the sense of Peirce's concept of habit, but in the sense of Pierre Bourdieu's *Language and Symbolic Power*, Polite Press, 1991), on the other.

14 From an epistemological (or, more broadly, philosophical) point of view, absolute propensity is of noumenon category and relative propensity is of phenomenal category (if we return to Kant's terminology).

15 Here we have a species of the so-called inverse probability problem – more generally of obtaining the probability distribution from the sequence of results generated by repeating the experiment. We can draw the obvious conclusion that propensity (at least absolute propensity) is robust (or inert) to counter-factuals. Even more important is to point out that propensity cannot be conditional (we will return to this assertion more analytically) because conditionality (e.g., as we know it from probability theory) is given by a fixed event in the event field of the probability space in question, not by the set of conditions for the manifestation of the probability of an event (also fixed). Now, in the case of propensity, the relative propensity, or that objectifi d into (Popper argues) objective probability of the singular case, depends on the absolute propensity and on the whole framework of experimental conditions (on the whole disposition of the 'propensity field').

16 Note that in the case of the sequence of outcomes (which, as we know, generates the objective frequential probability), the experimental conditions must be kept invariant for each repetition of the experiment; otherwise, the outcome sequence boundary of the experiment will not 'deliver' the probability. Even if the sequence is not infinite, if invariant maintenance of the experimental conditions is achieved, what is obtained is, with certainty, the objective frequential probability, even if, due to the non-infinity of the sequence, it has an approximate character.

17 Popper (1978) said that propensity plays the same role for probability as acceleration does for force (second law/principle of dynamics in Newtonian mechanics).

18 While virtually accepting the possibility of a sequence of repetitions of the experiment, Popper also does not specify whether this sequence must be infinite (being virtual, infinite experimentation is possible), or finite, and if finite, he does not specify whether the sequence must be long (how long?) or short.

19 It should be recalled that relatively recently, econometrics has begun to take into account the so-called latent variables (unobservable variables but which can be inferred from observable variables via the econometric model). However, the significance of the concept of latent variable in econometrics has nothing to do with the latent nature of propensity, except perhaps in the (superficial) fact that both propensity and late t variable are unobservable.

20 Econometrics does not take into account the dispositional context when, based on the estimation of parameters of past kinematic correlation functions, it claims to make

predictions. Extrapolating a trend (so-called phenomenological extrapolation) ignores the fact that the trend itself (in this terminology, the relative propensity of the phenomenon in question) can be (and necessarily is) modified by the future context, that is, the new dispositional property in which that event will unfold. But this is not the major 'sin' of 'article-writing' econometrics but the fact that it (worryingly frequently) treats stochastically phenomena that are deterministic in their essence. Presumably, just as Bayesian econometrics was developed after neoclassical econometrics, a *propensive econometrics* (i.e., based on propensive probabilities or, more precisely, on the relative propensity of the singular case) should be developed after the latter.

21 Indeed, Popper shows that the justification for deriving the objective probability of the singular case from the propensity lies in the fact that if we ran a sufficientl long sequence of identical experiments – that is, under the same experimental conditions – we would most likely obtain a probability value equal to the propensity. Here arises a particularly difficul problem, unresolved in the specialty literature: if the propensity is not necessarily a number, how does one make the transition from the propensity to the probability, which is instead a number? Even if we accept propensity as the basis of the objective probability of the singular case, we still need a (mathematical type) operator that maps (biunivocally?) propensity to the probability it generates.

22 In fact, Popper associates himself in this respect with David W. Miller (1995).

23 Popper was no doubt spurred on in his proposal of a propensity theory by Einstein's stance, who vehemently rejected the quantum model based on empirical (objective but not frequential) probabilities, saying that this theory was at least incomplete for this reason.

24 Lewis uses, for belief, the term *credence*, not *belief* (much less *faith*), to suggest that it is a form used by the individual to believe reality with a certain tendency (or, in the terminology here, a relative propensity). Essentially, the principal principle says that belief, conditional on theory and history, is equal to chance (i.e., the probability of the singular case).

25 It should be noted that in a deterministic universe, chance (as well as propensity or probability, by the way) is trivial: they have either the numerical value '0' (impossibility) or the numerical value '1' (necessity). It does not matter whether indeterminism, which gives the 'right of existence' to chance, is generated by lack of knowledge or, on the contrary, is a radical indeterminism, as in the case of quantum theory. David Lewis proposes, in fact, two versions of the principal principle (which, ultimately, is a logical analysis of chance): (a) the first version is formalized as follows: $P\left(A \mid T, H\right) = P\left(A\right)$ where P denotes probability, A is a statement, T is a theory that underlies belief, H is a history of the event described by the statement, and '|' is a logical constant meaning that the probability of the statement is conditioned by another event (or other events, as we have this case); (b) the second version is formalized as follows: $P\left(A \mid T, H\right) = P(A \mid T)$. So, if in the first version, we have an absolute probability, in the second, we have a conditional probability. It should be noted that determinism implies predictability, but the reciprocal is not true: predictability does not imply determinism (e.g., predictions can be made on a stochastic basis) (Johansson, 2009).

26 Note that neither Popper nor the vast majority of researchers in this field have suggested such an absolute property – they have shown that propensity manifests only within a given set of conditions. For example, in White's view (White, 1972), the mass of an object indicates a propensity for that object to move by itself towards the gravitational centre of the space in which it is located. But it is precisely the gravitational property of space – that is, the set of conditions – that causes the object to have that propensity; if gravity were zero, that object would exhibit no propensity. Note that Aristotelian physics had roughly the same view of an absolute propensity of objects (physics proven false by Galileo's studies).

27 One of the creators of pragmatist philosophy, alongside William James, in addition to his fundamental contributions to semiotics.
28 By *habit*, we imply a regularity (*Nota bene*: roughly in the Hume-ian meaning), an acquired law, or a general law (such as the laws of coverage in syllogisms). Human interprets the symbol by habit (*Nota bene*: we will 'argue' that by preference/propensity, human interprets behaviour, not information, as Fama claims in his EMH theory).
29 It is obvious that White's previously mentioned term *liability* (*it does be*) is inspired by Peirce's '*would-be*'.
30 Consistent with himself, Popper shows that 'would-be' cannot be a property of something but a relationship between that something and the conditions (environment) in which that something manifests itself. Yet, the full manifestation of 'would-be' is only in infinite sequences, and that is why 'would-be' (as a property) can also be applied to singular cases.
31 Laws that do not deal with fundamental issues are called phenomenological laws and are considered superficial laws (*Nota bene*: of course, not in the pejorative sense of 'civil' language).
32 He is the brother of the famous and important representative of the Austrian economic school Ludwig von Mises (the latter is credited with creating the concept of *praxeology* – spelled with an 'e', not as in praxiology – which is a sociological theory of economics, distinct, however, from sociology).
33 However, this focus had already been achieved by Kolmogorov in 1933 with his axiomatic theory of frequential probabilities (based on the axiomatic set theory). It should be noted that Kolmogorov's theory is a mathematical theory, while propensity theory (Popper's) is a logical theory – for example, propensity theory, being applicable to the singular case, can be used in the theory of judgements (syllogisms), in the sense that the major premise of a syllogism (or universal law or, again, covering law) has a certain propensity that, in the set of conditions provided by the minor premise, it generates the conclusion of the syllogism.
34 That is, an initial – *a priori*, as it is known in the literature – Bayesian probability (more precisely, an initial or *a priori* probability distribution).
35 It is obvious that, under Bayesian conditions, the objective probability on which the Bayesian *a priori* probability is based cannot be of the frequential probability type, because the Bayesian probability is associated with the singular event.
36 That is, what Popper called the dispositional property of an entity credited with propensity.
37 The reference class is obviously narrower than Popper's dispositional property – specificall , it is local, although from a theoretical, not experimental, perspective.
38 The principle of the narrowest reference class is not without problems: (a) there may be several equally narrow reference classes, between which an additional criterion of choice is needed; (b) even if there is only one narrow reference class, there is the possibility/risk of considering conditionals from another reference class, thus altering the probability that the propensity of the reference class would have generated without the interferences from another reference class (Keynes drew attention to this problem).
39 Obviously, Gillies considers that the identification of the reference class (possibly the narrowest as a sphere) is a subjective fact which thus gives probability, even if not propensity, a subjective character. Finally, it seems that Gillies accepts, for (subjective probability of) the singular case, at most an objective basis, represented by propensity.
40 Recall that Lewis, elaborating the second version of the principal principle, dropped the absolute probability $P(A)$ and replaced it with a conditional (more precisely, non-fundamental conditional, in the terminology introduced by Gillies) probability $P(A \mid T)$.

41 In this sense, Kevin Hoover (2002) speaks of a stability of expectations about social regularities. Clearly, here the fundamental role is played by the normative framework, which we will consider (from an evolutionary approach perspective) as the environment in which the 'species' called adaptive preference evolves, which contains the 'individuals' represented by trading strategies in the financial market.

42 Simboli's position (Simboli, 2017) is obviously Aristotelian, since Aristotle considered that there is no science of the contingent (here the question arises whether economic theory is science or not, since it deals with the contingent, not the necessary).

43 This definition of probabilities is considered the naive definition of probabilities (the scientific definition was made by the axiomatic theory of probabilities, proposed in 1933 by the mathematician Kolmogorov).

44 Note that the objective frequential probability should be considered as an epistemological probability, not a causal one.

45 More precisely, probability operating in the quantum domain, since probability, as a numerical value, cannot be quantum but only continuous – for example, the set of natural numbers (as well as rational numbers, for that matter) is a 'quantum' set, that is, discretely countable, whereas the set of real numbers, in which the numerical values of probability fall, more precisely, the interval $[0,1] \in \mathbb{R}$, is a continuous set, and hence non-quantum.

46 Here one can see how much harm can be done by a carelessly assigned name – the 'objectivity' of the frequential probability results, of course, forcibly, from the fact that the experiment is repeated over a long (borderline infinite) sequence of outcomes, thus presuming that the repetition of the experiment is outside the 'jurisdiction' of the subject.

47 Induction is known to be susceptible to falsehood, although it does not necessarily generate falsehood (see Russell's chicken or Hempel's crow example). Logically, however, induction is not of the *ex falso quodlibet* type, a principle also known as the principle of explosion.

48 Regarding the anteriority of cause to effect (anteriority that can be measured only by measuring a higher entropy world containing the effect against a lower entropy world containing the cause), quantum theory has something to 'object' to – it turns out that time, at least clock time, is reversible in the quantum world, so the effect can precede the (effective) cause.

49 There are authors who consider propensity as a cause of cause. In other words, this would mean that propensity acts causally to trigger the efficien cause. Such an interpretation makes very strong sense (and is useful both theoretically and operationally, i.e., methodologically and instrumentally) in the economic field (i.e., more broadly in the social field). In these domains, propensity could be seen as a final cause triggering an efficien cause. In the remainder of this study, in which we will consider (adaptive) preference as a propensity of the individual's habit (or habitus), we will detail and deepen this assumption of the authors.

50 The stochastic model is in fact a propensity distribution. In other words, the distribution of outcomes (at the limit, the probability distribution) is the observable expression of the distribution of propensities.

51 The name *Humphreys' paradox* was given by David Fetzer (mentioned earlier), not by Humphreys himself.

52 Recall that this symmetry underlies Bayes's theory of subjective probabilities on the singular case (event).

53 In our study, however, we will accept the symmetry (in fact, a certain symmetry or, more precisely, a restricted symmetry) of propensity (which we will identify with preference). Of course, in due course, all the considerations that support (or aspire to support) such an epistemological position will be given.

54 This is why econometrics (more generally, quantitative models applied to stochastic processes) cannot establish causes, but only correlations. Although, in our view, operationally and even from an economic policy perspective, correlation is sufficien to generate quasi-explanations (not pseudo-explanations), the claim of econometrics (or, more precisely, the irrepressible obstinacy of econometricians) to identify causal relationships is not only misguided but also annoying in the arrogance it displays (let there be any doubt of some hidden anti-econometrician passion, we concede that predictions can also be made on the basis of correlations, not necessarily on the basis of causality, of course if all measures are taken to 'guarantee' that the established correlations are maintained over the predicted period, a point most often omitted by writers of applied econometrics articles).

55 In fact, that's exactly how we're going to do it.

56 Popper's approach is obviously an approach from a logical perspective, not a mathematical one, much less an operational one (such as Kolmogorov's – mathematical – theory of probability). Note that Keynes himself, in his concerns about probability, also uses a logical approach.

57 We do not wish to depart from the conception of empirical testability, although we will also examine coherence testability (grammatical and semantic, respectively), because we remain convinced that the only genuine criterion of scientificity (primarily because it is, in turn, inter-subjectively testable) is factual testability (or falsifiabilit , in Popper's terminology). As is well known, the separation between positive statements and metaphysical statements was made, systematically, that is, from the perspective of the philosophy of science, by the representatives of the Vienna Circle (logical positivism, later called logical empiricism), with which, without being a member 'with documents', Popper himself flirted, before he invented falsificationism as an alternative to verificationism (the dominant conception of testing within the Vienna Circle).

58 Although there are authors who are unwilling to give up this qualification (Settle, 1972).

59 Here there is obviously the difficult of making a predictive statement about a numerical value (the objective probability value of the singular case, or chance value, in Lewis's terminology) (Lewis, 1980) on the basis of a non-numerical cause (or one to which no numerical value can be attached). As we said earlier, the problem of 'assigning' a numerical value to the propensity (*Nota bene*: this is a single value, not a set of possible values!) is not only unsolved (yet) but also no (ingenious) way to do it is in sight.

60 The accuracy of the terms used in this sentence is not very high, because, as we have shown, propensity cannot be assigned a numerical value that can be (quantitatively) changed, no matter by what means and with what justification.

61 We note that there are views in the specialty literature that the concept of conditional probability (which is contained – like the Bayes theorem – in the Kolmogorov's axioms of probability) is inadequate to the concept of probability itself (Hajek, 2003).

62 Of course, it is also possible to redefine conditional probability so that it does not depend on one event but on a class of events, chosen according to pre-determined criteria. Recall that in formulating the principal principle, for example, Lewis conditions probability not only on theory (which could be considered a fixed event) but also on history, which means that we have conditionality extended from the orthodox concept of conditionality.

63 There are 'disagreements' about what exactly the long term means. Thus, (Gillies, 2000) considers that long term means a finite but very long sequence, while Fetzer (1981) considers that the sequence in question should be infinite (thus, somewhat returning to Popper's position, who accepted a virtual infinite sequence – *Nota bene*: an infinite sequence cannot be anything but virtual, like any passage to infinity)

64 Recall that the EMH does not allow degrees – in fact, this is one of the reasons why alternatives to the EMH have developed: behaviourism, evolutionism, and adaptivism.

65 In other words, probability theory should be called possibility theory.
66 A lexicographic ordering is an a-criterial ordering, generated by a procedural logic that the author of the ordering proposes. This means that the only way to examine and evaluate a lexicographic ordering is to reveal that it produces a procedure that achieves the objectives proposed in the research/modelling in question. In other words, a lexicographic ordering is an ordering that delivers a deductive model appropriate to the purpose of that ordering. Of course, care must be taken that the deductive model produces the possibility of factually testable statements, that is, scientific statements (in Popper's sense).
67 Fama: EMH; Lo: AMH.
68 Previously called geodesic. We will retain the concept for which, however, a term will have to be found from the jargon terminology of financial markets.
69 So, propensity relativity refers to the set of local conditions (of space, time, regulatory framework, etc.).
70 Again, we refer to the example provided by Herbert Simon with his concept (and term) of *satisficing*, that is, we make a verbal combination of propensity and preference – hence, *proference*.
71 If the uncertainty is not complete, then of course the probabilities in the *a priori* distribution will not be equal to each other. In fact, proference is meant to identify the maximum subjective probability in an initial probability distribution.
72 The *Finite Difference Method* (FDM) is an approximation (of various orders as needed) of the derivative of a continuous function around a given point to a sufficientl small neighbourhood, according to a convenient approximation size. The method is useful from at least two perspectives: (a) it can find numerical solutions (including by computational computation – e.g., using *Python* programming software for the social sciences), where finding analytical solutions (i.e., function-solutions) directly from the differential (or partial-derivative, as the case may be) equation is difficul or even impossible; (b) it linearizes the differential or partial-derivative model, if it is non-linear, which allows the use of matrix algebra to solve the resulting system of linear equations (*Nota bene*: the use of the finite difference method can lead to systems with a relatively large number of equations but which are algebraic, that is easier to solve).
73 Without further questioning the *homo œconomicus*-like conditions implied by EMH that are needed for the integration of historical information into price (discussed at length in Chapter 2) and also without further questioning the absence of description of the mechanism for integrating information into price, an absence of which EMH is 'guilty'.
74 This is the so-called event information – event analysis is one of the most 'frequently used' financial market analyses and one of the ways in which one attempts to test (corroborate vs. refute) EMH or other financial market models.
75 We note that, in our assessment, the AMH provides no mechanism by which information (or behaviour) is taken into account in the adaptation process – not to mention the fact that this model provides no systematic and coherent description of the claimed adaptive mechanism. Instead, our research will propose solutions for both theoretical and methodological tasks in this regard.
76 In a way fully analogous, here, to the concept of (essential) tension used by Kuhn in describing the mechanism of operation of the concept of paradigm (see Thomas Kuhn's work, *Essential Tension*).
77 More precisely, on account of the propensity associated with preference, that is, with the term proposed earlier, on account of proference.
78 In Lo's view, the environment for trading strategy is the financial market. As we have already shown, our view is differe t, namely, that the environment is the normative framework (in fact the habit or habitus or, still, the cultural – primarily normative – geodesic of the given economic-financial system), and the individual is the trading

strategy that leads to the evolution of the species (by the latter we mean the financial market).

79 Effectiveness refers to an above-market average gain under arbitrage, and efficienc refers to a net gain relative to the monetary expression of the cost of risk-taking and information-seeking.

80 We prefer the phrase *meaningful information* to *relevant information* because relevance cannot result from a simple semantic examination of the information but (also) from an examination of the quantitative relationship between the content of the information and the significance threshold accepted by the economic agent in question (the significance threshold is, of course, highly idiosyncratic, as is preference or, more precisely, proference).

81 The term (and concept of) *white information* is semantically similar to the term (and concept of) *white lie*: that is, information that has no external impact on the 'target' (like the white lie), although it may have an internal role (or from internal perspective).

82 In the sense of an indivisible unit of a population, considered in the abstract.

83 Obviously, here we have a 'confirmation' of the fact that, strictly speaking, one cannot speak of an informational efficienc of the market (as Fama does) but of a behavioural efficiency (or efficiency of an objectified informati

84 We bring to the reader's attention an analogous 'case' from sociology (more precisely from social systems theory), namely, the case of the autopoietic model proposed by the German sociologist Niklas Luhmann (2012), which one of the authors of this study criticized, proposing an alternative structure (including an alternative phenotype) of a possible autopoietic social model (Dinga, 2021c). In that theory, the phenotype – that is, the entity that interacts with the environment and is selected by the environment – is the communication (as a performative act within social interaction), not the human individual, although, obviously, no act of communication can take place outside the human individual (since communication involves signification, and signification cannot be automated, it is the inalienable prerogative of consciousness, which is exclusively, inherently, and irrevocably human). However, in Luhmann's model, the human individual is considered, analogously to our proposal in the present study, as an exogenous supporting factor of the autopoietic mechanism (in our case, of the (co)evolutionary mechanism). Somehow – we add – the human individual is, in Luhmann's view, precisely, the propensity that leads to the probability of communication.

85 The greatest degree of sophistication, even within contemporary sophisticated capitalism, is obviously in the financial domain. This is by far the area that sets the 'tone' for sophistication (both conceptual and operational) in economic markets.

86 Even if, in advertising or in various rankings of the rich people of the planet, the names and surnames (i.e., elements of civil status) of single biological individuals appear, they act (and acquire their wealth – more or less deserved, in the sense of social justice) through organizations (usually financial funds – venture, mutual, investment, index funds, etc.).

87 It is of no interest here that we associate a probability with each of the hypotheses of the phenomenon, whether it is a frequential probability, a subjective probability, or (as we shall do in the economy of the study) a propensity probability.

88 And obviously in contrast to Lamarckism. We shall see, however (*Nota bene*: we have also referred to this point previously), that in the financial market (more generally, in the economic and social fields), Lamarckism is taking its 'revenge' – an increasing part of social evolution is of the Lamarckist type. Incidentally, the critique of EMH (and partly, also of BMH) is based on the observation, pertinently, that the Darwinian-type evolution of the human individual has not kept pace with the evolution of institutions (including financi l institutions), that is, their Lamarckist evolution. We will examine, elsewhere, the relevance (and justification) of this Lo-ian observation.

89 The distinction (very important from the perspective of economic theory) between growth and development processes is not relevant here, and we therefore consider them semantically (i.e., referentially) equivalent.

90 It can be seen that we have kept the meaning from biology here: the individual (phenotype) grows/develops as the species evolves. Although in common ('civil') language, this distinction is ignored (without much loss of meaning) – for example, we sometimes hear it said that an individual has evolved – in scientific jargon, it is well be respected.

91 For the concept of fetality as applied to reaction norms, we refer the reader to Chapter 2.

92 Epistemologically, both methodological individualism and methodological holism are reductionisms – both reduce, explanatorily, one entity to the other (by substituting explanans for explanandum) – which is why we insist, in this study, that the methodological holism that will be used in the design of the equational model of adaptive preference is a 'weak' one, in the sense that, while we accept a dominance of the whole over the parts, we grant the parts an active, not simply passive, role (this active role manifests itself, as we have also shown, even at the generic level: IT generates FM).

93 The most 'usual' meaning of the concept of society is, at this point, that of the nation (or nation-state). There are also attempts (more or less successful, more or less viable) to transcend this level – for example, the European Union or the emerging Eurasian Union – to a regional supranational societal structure. In principle, a global society is obviously possible.

94 Obviously, an absolute propensity would logically imply a tendency/inclination unconditioned by (environmental) conditions. For example, the absolute propensity of a coin tossed in the air would be to fall either heads up or tails up. But, for example, if there were no gravity, a tossed coin would move away indefinitely without ever falling again to demonstrate its absolute propensity, so absolute propensity can only manifest itself under given (however general) conditions. Recall that it is precisely this set of given general conditions in relation to an experiment (but, of course, equally in relation to an experience), proposed by Popper in his second meaning of the concept of propensity, that led to the concept of relative propensity (*Nota bene*: but, beware, not to the concept of conditional propensity).

95 The concept of observation or observable is not without semantic controversy. In this study we will understand by observation a recording of a change of state produced in a system (objective or subjective), a recording made in whatever way (the essence of recording is, in any case, that of memorization) by a human subject or by a device interposed between the human subject and the observed object. Thus, an observable is a variable that undergoes a change of state, however that state is defined. To draw a parallel (we think, a useful one) with biological systems, if a prey-animal stands still – that is, does not change its state of confusion with the environment, which is, by defin - tion, still – it will not be observed by the predator-animal. Instinctively, this is 'known' by both the prey-animal and the predator-animal. But this concept of observability can be generalized, as we did earlier.

96 If we consider the agent/organizational individual, of course, preference will take on the character of an inter-subjective objectivity, as is any social object – institution, behaviour, and so forth. In the specialty literature, we speak of so-called social constructionism (Berger & Luckmann, 1991).

97 Taken, as we know, by EMH, up to invariance.

98 We do not develop here the family of concepts on the general dynamics of systems, but let us note that there are the following 'stages' in such a dynamics and in its relation to the subject involved: (a) observability, (b) accessibility, (c) controllability, and (d) command.

99 The term (and concept of) *occasion* has here the meaning it has in *praxiology* (*Nota bene*: not to be confused the term (and concept of) *praxiology* used by Tadeusz Kotarbinski – the theory of efficien action – with that of *praxeology* used by Ludwig von Mises – the sociological theory of economics).

100 It does not matter, obviously, the numerical size of this 'maximum' probability – what matters is that, in the probability distribution accepted by the economic agent, one of them, which refers to a particular hypostasis (*occurrence*) of the event of interest, is the largest of all (*Nota bene*: we keep, for the time being, the Kolmogorov condition of sum equal to unity of all probabilities in the probability distribution; later, towards the final part of the research, we will also adopt the perspective of the so-called extended probabilities, which 'violate' two conditions of Kolmogorov's axiomatic probability theory, accepting both negative probabilities and sum different from 1 of the probabilities composing the probability distribution for an exhaustive field of events).

101 It is, in fact, about the deviations between propensity and probability.

102 The concept of propensity has, of course, been 'accused' of being metaphysical in nature (Settle, 1972), because, on the one hand, it has been said that it cannot be tested as such but only by means of preference, and, on the other hand, it has been argued that, although propensity can generate probability (usually subjective), probability cannot 'return' to propensity (possibly to modify it) – we recall that this is precisely the so-called inverse probability problem (Albert, 2007). In other words, even if we can conceive of an adaptive preference, we must be able to show that its modification is also claimed from the modificat on of propensity, somehow; otherwise it would follow that preference is the effect of propensity only on the occasion of the 'first fillip', and thereafte , it behaves autonomously in relation to propensity.

103 Here we obviously have a particular type of co-evolution, which we propose to call *symbolic co-evolution*. We will show, in the later parts of the research, that in addition to the economic utility of the 'correct' choice of trading strategy (e.g., gain above the financial market average), the economic agent also receives a symbolic utility – for example, success or recognition of market position. It is the symbolic co-evolution that ultimately directly 'returns' the impact from the trading strategy to the preference (as for the further transmission of the impact from the preference to the propensity, this is an issue of a different nature, which will be examined separately).

104 Logically, it is impossible to reject such an impact. Rejecting it would lead to the following theoretical (and also methodological) consequence: since preference is an objectification of propensity, if preference cannot in turn influence propensity, it follows that the latter is somehow invariant. But if propensity is invariant, it follows immediately that preference must also be invariant, as a direct manifestation of propensity. But this last result sends us straight back to the EMH and removes us irrevocably from the concept of adaptive preference. This means that we must somehow find a way in which preference 'turns on propensity.

105 Bayesian probability is discussed, in some detail, in the Annex 2 of this research, relating to the probability problem.

106 Laplace formulated his principle of insufficien reason in his work *Essay philosophique sur les probabilités* (Bachelier, Imprimeur-Libraire, Paris, 1814). Keynes calls it the principle of indifference (*Nota bene*: in fact, it is not at all a principle of indifference, although, perhaps, in the sense that, all probabilities being equal, the numerical value of one probability can be substituted for the numerical value of any other probability, the sum of the probabilities remaining invariant – which is, however, commonplace).

107 It is acknowledged that the shift of uncertainty from complete (pure, radical) to incomplete is of an emotional nature rather than a cognitive nature. In other words, uncertainty is reduced at the affecti e level, through preference/belief, rather than the logical or rational level.

108 As we will see, although Bayes theorem implies new information modifying the *a priori* distribution, we will replace information by behaviour, as argued in Chapter 2, so that adaptive preference (and thus also the choice for the trading strategy, i.e., the individual transaction) will be shaped by behaviour, not information. So, we reverse the causal relationship: it is not information that causes behaviour (as reasoned in the EMH case) but behaviour that causes information.

109 For example, competition (like monopoly/monopsony or collusion) always takes place between economic agents of the same class – between sellers, that is, between buyers/investors, not between agents of different/opposite classes (thus, between buyers and sellers, there is a process of negotiation/exploration, not a competition).

110 Coalitions might be legal or illegal; in the latter instance, we're talking about collusions or collusive structures.

111 See, here, the concept of cultural geodesic.

112 Of course, some agents, depending on their rationality (or, equivalently, preference) model, may choose not to integrate free information (either fully or partially) – for example, those who decide to commit tax evasion or conduct illegal commercial transactions. In this case, a so-called cost of non-compliance arises, which is a potential cost, although some more sophisticated agents (as Fama would say) may introduce this cost (and risk) into their decision optimization calculations (Becker, 2009). Note that, in this case, we have a cost not of information-seeking but of information avoidance/ignorance. This is hardly addressed in the specialty literature on financial marke functioning.

113 Event analysis is one of the most numerous empirical approaches in the specialty literature devoted to financial market functioning, especially in the EMH margin (*Nota bene*: note that event analysis is semantically very close to behavioural analysis, to which we will refer later).

114 We recall the concept of implicit cost: a cost which is not an accounting cost but which counts for the calculation of profit (e.g., for an entrepreneur who works in his own firm without paying himself a salary, that salary is an implicit cost which, although it does not count from an accounting point of view, does count from an economic point of view – the nominal profit obtained must be reduced by the value of the salary in question).

115 Decision and behaviour which in turn constitute events containing implicit information for other financial market agents in what is called the financial market information network (Onnela et al., 2006).

116 As will be shown, EMH has not taken into account that the information acquired (through any of the three routes discussed) simply will not be used as it is not compatible with the preference (proference, in our terminology). Yet, this aspect is crucial even for empirical testing of the EMH, so much so that we believe if it were introduced into the factual tests operated in the EMH margin, many 'clear' results would now prove less decisive or even reverse their significance.

117 The EMH (and the studies driven by this model) does not 'complicate' the issue at this point – in the view of this physicalist model, all economic agents use all available information. We will see, however, that preference obfuscates some information that is not compatible with it. Like science (which sees from the world only what it knows about the world), preference sees from the informational world only what is compatible with it. This 'blindness' (or myopia or, still, 'blind spot') generated by preference/proference is of the greatest importance and significance in the present study and, to an important extent, in the studies that follow. Things are the same with the functioning of the Kuhn-ian paradigm – there is, too, a 'blindness' to the results that do not fit into the puzzle or exemplary problems or solutions.

118 The Karnaugh diagram is used for minimizing Boolean algebraic expressions, but, adapted, it is very useful when we have to make classifications according to several criteria simultaneously.

119 As stated earlier, any additional costs (searching for information, processing it, hedging the risk) must be covered by the return obtained on the financial market, so as to obtain a positive net result, whether or not that return is above the medium market level.

120 This cost is, from another perspective, used as a paravane for artificially increasing tax-deductible expenses so as to reduce the tax base of the profit – this is what the literature calls legal avoidance, that is, the agent in question already has the information that he will 'acquire' as a result of the consultancy studies but he mimics the cost of acquiring it (*Nota bene*: as a rule these cash flows circulate within the holding companies, so the money stays within them, only losing its trail).

121 It refers to the overhead costs of searching/identifying the data store to be stolen as well as the costs involved in actually carrying out the theft operation.

122 By analogy with the liquidity trap: the minimum limit of the nominal interest rate below which any fall in this rate no longer influences the money supply on the money market (*Nota bene*: do not confuse the money market or short-term credit market with the financial market, the latter being, in principle, a long-term 'credit' market – obviously, here the expression 'long-term' does not have calendar connotations: a financial security is a long-term 'credit' security even if it is traded daily or even sub-daily).

123 See note 122.

124 The idea that the self-regulating capacity of the (financial) market is directly proportional to its depth is a problem per se and will not be discussed in this study. This idea is also at the heart of the ideological debates between libertarians and advocates of a broader market-state mix.

125 The curves were mapped out in Matlab with the following programming sequences, namely, (a) for α_x: x=[.13:.01:1]; y1=.11./x; plot(x,y1); (b) for α_z: x=[.13:.01:1]; y2=1.32.*x-1.32.*x.^2; plot(x,y2); (c) for α_y: x=[.13:.01:1]; y3=(-.11+x-1.32.*x.^2+1.32.*x.^3)./x; plot(x,y3).

126 Recall that a logistic curve is an analytical solution (so a function) of the Bernoulli differential equation ($y' + P(x) \cdot y = Q(x) \cdot y^{\alpha}$, where $P(x)$ and $Q(x)$ are real polynomials in x). The logistic equation is $y = \frac{1}{C + e^{x}}$ or, equivalent, if, by the initial conditions, $C = 1$, $y = \frac{1}{1 + e^{-x}}$.

127 The inflecti n point, on the abscissa axis, is obtained by making the condition that the second derivative of the function in question is zero, so the function must be of class C^2 (i.e., it is a continuous and double derivable function).

128 The amount of information, in (subsequent) formalizations that are compatible with empirical testing, will be modelled using the Shannon equation or the Boltzmann equation, as appropriate (both of which call for a micro-level grounding of the macro level, as is well known).

129 Note that the distinction between public and private information which, together with the distinction between outside and inside information (a rather strange and ambiguous classification, by the way), which led to the three types of financial market information efficiency is less relevant than the typology we propose in this stu .

130 The typology of market informational efficienc (strong, semi-strong, weak) is, however, a vague attempt to disaggregate information categories but from an exclusively qualitative perspective, difficult to test empirical .

131 We recall that in the EMH, only one category of economic agents is considered, namely, the rational ones (more precisely, the hyper-rational or sophisticated ones, as Fama called them), a natural logical consequence of the fact that the EMH is

the behavioural/praxeological reflection of the cognitive model called *homo œconomicus*.

132 We can also make a legal argument in favour of our assessment here, namely, that no one is exonerated from the guilt of not knowing the public rule. The regulation of the organization and functioning of the financial market is a matter of public law (the publicity of this type of law is ensured by publishing the law in a publication specifically intended for this purpose – in Romania, for example, this is the Officia Monitor of Romania). There are, of course, other rules that must be respected – for example, statutory rules, specific to each organization, especially since, in today's world, economic agents are less and less individual and more and more organizational, or the norms specified in the contracts between the parties (obviously, neither some nor others are contradictory or incompatible with legal norms which, in turn, are not contradictory or incompatible with constitutional norms).

133 They will obviously be credited with relatively low ethical competence.

134 This does not mean that they should be considered hyper-rational (as Fama does) but only that they are economic agents with a greater capacity for attention and reflection, or that they have a greater inclination in this direction – as such they will be considered as having a relatively high resolutory competence (it should be noted that this resolutory capacity can simply be of a heuristic type, i.e., based mainly on an attentive and reflective attitude towards the kinematics of the fina - cial market).

135 In this sense, one can talk about lags (delays) or leads (anticipations) of information inferred from observing behaviours. We insist, here, on the idea, already expressed, that all information is generated by behaviour, that there is no information without behaviour (although there can be behaviour without information – we can call these behaviours black boxes, as is done, moreover, in systems theory: a black box is a behaviour or a system that contains, or is presumed to contain, a behaviour from which no information 'emanates'. *Nota bene*: of course, there may be degrees of 'blackness' of the box in question, depending on the resolutory capacity of the agent (e.g., until Champollion, Egyptian hieroglyphs were absolute black boxes for archaeologists)).

136 We will use the 'barbarism' financial individual to refer to those individuals who act on the financial market – for example, poets or monks or research economists will not fall into this category (unless the latter are somehow following Keynes's example or are somehow econometricians). Moreover, in the terminology used in this study, the term *economic agent* (or, often, agent) must be considered synonymous with the term *financial individual*.

137 Note that these hypotheses are naturally opportunities for empirical testing, analogous to the opportunity generated by Fama's 'sentence' that prices have already included whatever information is available. Incidentally, in due course (when we discuss the testability of adaptive preference), we will resume these hypotheses, this time from the perspective of falsifiabilit .

138 The curve appears to be symmetrical, but of course, this is a stylized (and didactic) way to present things – the parabola can be asymmetrical, and this asymmetry will depend on both the psychological and the normative (cultural geodesic) aspects of the economic system (or society) in question. The same comment applies to the convex parabola in the same figure.

139 Categorical knowledge refers to the fact that we integrate a received information in the model (explanatory pattern) into which (it seems to us) that information fits. Categorical knowledge is a solution that consciousness has found to the siege exerted by the abundance of information (*Nota bene*: in fact, our brain has found another solution to this siege: it is meta-knowledge – for example, here, systems theory).

140 We call this paradox the *inferentiality paradox*. The paradox is, in fact, a reversal of the inferentiality of information in behaviour, from the perspective of an economic agent who witnesses the deepening of the financial market.
141 We can indeed say that, while observational competence, and especially resolutory competence, are of the nature of skill, ethical competence is of the nature of attitude.
142 Here the word necessarily has its meaning from logic, that is, obligatory, *sine qua non*.
143 Possibility is essentially a non-frequential probability, so although it is objective and assigned to a singular event, it is not, as yet, a propensity – for a possibility to become a propensity (and hence a probability), it needs to become active through a process of choice/selection to which we shall return.
144 By visible information we mean public information available without search costs.
145 The concept of possibility (generated, in particular, by the fact that probabilities are definable as actualizations of possibility, ultimately) is to obey the same commands as the concept of probability. This means that a measure of possibility (like a measure of probability) must quantitatively satisfy the following mathematical conditions (*Nota bene*: these are exactly the Kolmogorov conditions for objective probability): (1) it is positive and sub-unitary (so, not being strictly positive, it can even take the value zero: impossibility); (2) the possibility of the necessary (subjectively certain) event is 1; and (3) the sum of possibilities, for an exhaustive distribution of possibilities, is equal to 1.
146 Recall that two events are independent of each other if the occurrence of one does not condition the occurrence of the other (e.g., two rolls of a die – which can be either right or rigged – are independent of each other).
147 In principle, the amount of observed information is not without effect on resolutory competence (and even on ethical competence), but here we will disregard this dependence (in possible further analytical developments, a multiplicative correction coefficient can of course be added to introduce this relationship)
148 Let us recall the Weberian theory on the impact of Protestantism (*Nota bene*: which is a type of cultural geodesics 'coloured' strongly from a religious perspective) on economic values and, implicitly, on economic decision-making and behaviour.
149 This article was reprinted in 2015 in the *Springer Handbook of Computational Intelligence* (pp. 31–60), edited by Janusz Kacprzyk and Witold Pedrycz.
150 By correct term, we mean the term that corresponds rigorously (semantically, i.e., referentially or denotatively) to the concept involved (we always talk about concepts but not using the concepts as such – this would be practically impossible – but the terms that designate those concepts).
151 Unless we are dealing with a deterministic model, but this hypothesis already takes us out of the realm of the stochastic, so there is no point in discussing possibilities, probabilities, or the conceptual relations between them.
152 See, here, the extensive discussion developed earlier on the concept of propensity.
153 Empirical weights will need to be established through factual, contextual analysis (including, where appropriate, econometric tools).
154 Note here that, from an epistemological point of view, the hypothesis/conjecture we propose (the linearity of total information permeability formation) is fully testable factually, that is, it obeys the criterion of scientificity proposed by Poppe .
155 The suggestion obviously refers to the concept of geodesics in cosmology (also present in the theory of general relativity). A synoptic suggestion of the workings of cultural geodesics can be found in Figure 3.27.
156 Religious norms are usually considered divine or divinely inspired norms, so they are not positive norms (the latter representing cultural institutions of the individual or society), for example, the Ten Commandments of the New (or Old) Testament.
157 Kuhn's very concept of paradigm can be subsumed under the concept of situational framework and even, more restrictively, under the concept of (sectoral) geodesics.

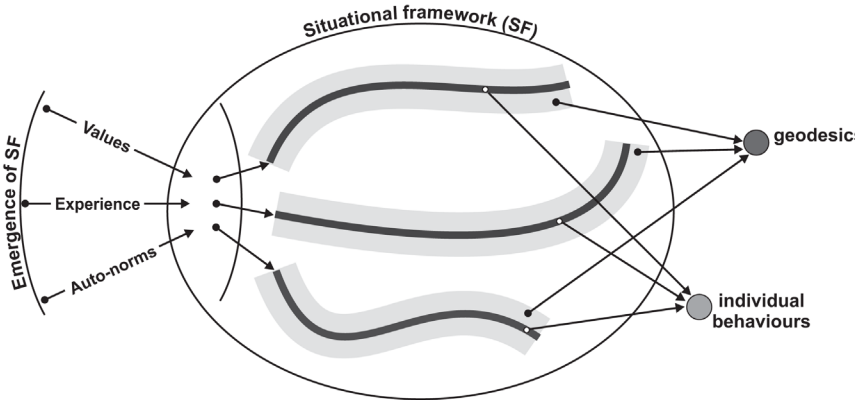

Figure 3.27 Situational framework (with its generated cultural geodesics) and behaviour.
Source: authors.

Indeed, all the characteristics highlighted by Kuhn with regard to the concept of paradigm (cognitive, in his case, but there can also be praxeological paradigms – e.g., the EMH paradigm in the financial field – or practical paradigms – e.g., the libertarian paradigm in the political field) are to be found in the logical description of the concept of geodesics.

158 Obviously, here, the term *evasion* has its general meaning of avoidance, of circumvention, not that particularized to tax evasion (avoidance/bypass of budgetary obligations).

159 Basically, this probability is zero, but considering an infinite time, the probability becomes a certainty – it acquires the value 1 (we are in the presence of a situation similar to that in which the probability as a monkey pressing the keys of a typewriter at random for billions of years; it will end up writing all the works written by Shakespeare with a probability equal to 1).

160 As we have shown earlier, propensity is sometimes associated with natural events – Aristotle's example is most famous here.

161 From an epistemological perspective, it can be said that, for the individual, there is only the world that his theory of the world assumes.

162 It is understood that we adopt, here, the Aristotle-ian typology of the cause (typology to which 2 500 years of evolution of humanity have not added anything important!).

163 The lexicographical ordering of preferences allows only their ordinal comparison, not the cardinal comparison, but the ordinal comparison is sufficien from the perspective of the functioning of this ordering as a predictor for the decision and behaviour of the agent in question.

164 Often, following the announcement of regulatory changes (e.g., the amendment of a fiscal-budgetary rule must be announced, according to the Fiscal-Budgetary Strategy and the provisions of the Fiscal Code, at least six months before its adoption or entry into force, precisely to allow the economic system to avoid the shock produced or possibly to be produced by the normative change), the financial market and, therefore, the behaviour of the economic agents (hence, implicitly, the preference) change in advance in relation to the change of the norm contained in the formal information.

165 However, the idea of an adaptive preference that adapts because it has nowhere to go is debatable. Indeed, an economic operator cannot refuse to adapt his preference to

the new rules in the category of formal information, under the sanction of bearing the legal consequences. In other words, the question arises: since preference changes (or must change) imperatively (*Nota bene*: in logical terms, we say it must necessarily change), what other adaptability can we talk about? In our opinion, even in this case, we are dealing with an adaptation of the preference, for at least two reasons: (a) the adaptation of the preference is, however, at the discretion of the agent – he can, for example, refuse the adaptation, assuming – and bear – the costs associated with this refusal; (b) the adaptation of the preference is generated by reasons of economic survival (*Nota bene*: here is 'material' for reflections in a Lo-ian key), that is, it implies a certain rationality of this adaptation (therefore, a same modification of a norm related to formal information can lead to different adaptations – such as speed, intensity, direction, and so forth – to different economic agents).

166 We call causal error the decision that is made as a result of misunderstanding (or misinterpreting) the cause of that decision – what George Soros called fertile error (Soros, 2009).

167 The name of the herd effect is not exactly happy, because the economic agents who imitate (by meme) the observed behaviour of the other agents do not proceed completely a-rationally but decide (it is true, with a lower reflective effort than if they themselves drew conclusions from observing the behaviour) that this is a reasonable and worthy behaviour to follow. Therefore, the effort of the resolutory competence is not null, in this case, but is minimized, so to speak.

168 Therefore, we can also find on the financial market the equivalent of 'opinion leaders' in the media field, which we can call, *mutatis mutandis*, behaviour leaders.

169 We have, here, a hermeneutic stage that the agent has to go through in order to release the implicit information. Of course, hermeneutic competence is a component of resolutory competence.

170 Of course, the term *intelligence* is used here in a metaphorical sense, similar to the way we talk, in the specialty literature, about, for example, smart finance.

171 The term *bright cone* is used here in a metaphorical sense (and not too much!), by analogy with the concept of bright cone in the theory of special relativity, where it means that past events (and, incidentally, future ones) cannot be at all observed unless they fall into a 'cone' generated by the expansion of light from the big-bang onwards.

172 We recall that Fama (and others, in his wake) considered only two categories of agents: (a) sophisticated or rational agents, who, in the terminology used here, are agents with maximum (and infallible) resolutory competence; (b) unsophisticated or irrational agents who, in the terminology used here, are agents with minimal resolutory competence.

173 The descending order of this autonomy is obviously formal information, implicit information, and bound information.

174 The only partial inclusion of the agent's values in preference is an acceptable idea, in our opinion, because the values, which represent the main component of the agent's cultural geodesic, reflect on many coordinates of the plenary life of the agent who is not exclusively an economic agent but also an individual, citizen, and so forth of the society concerned. Thus, the agent may have/respect/share some values that have nothing to do with praxiology (i.e., economic action) but with the spiritual life – these values will not enter into preference, however, and will not enter directly/immediately or completely.

175 Here the term *phenomenology* is the Kantian term, not the Husserlian one.

176 Obviously, this is about the discrete mathematical concept. Solving one of the subobjectives of the research refers even to the possibility of discrete modelling of economic phenomenology on the financial market (more precisely, to the use of interval mathematics).

177 The metaphorical term *decree* has, moreover, a precise meaning from an epistemological point of view: it refers to the enunciation of conjectures which, in turn, can be

the subject of empirical testing. In this way, much clearer than EMH does and unlike AMH (which does not propose such empirically testable conjectures), our proposal on the mechanism of adaptive preference in the financial market is much more 'generous' in such testing suggestions, so according to Popper's falsifiability is much more testable than the other two models mentioned.

178 Therefore, it is not necessary for the (adaptive) preference to be objectified in an act (to do), but it is enough for it to be objectified in an abstention from the act (not to do). In the terminology used in previous studies in this research, the preference must, therefore, be objectified in an action – that is, in the genus that includes the species: act and abstention.

179 In fact, rather than expectations, as behaviourism has shown (although it has not yet produced a theory but is, for now, only a collection of observations and experiments that seem to indicate certain patterns of heuristic behaviour).

180 See here the concept of over-confidence which agents are credited with by the behaviourist vision.

181 In fact, we believe that this conjecture could be of the type of a driving conjecture.

182 The mathematical problem that arises here is this: as a given propensity can be the source (efficient cause) of several (not only one) adaptive preferences, the defining condition of an algebraic function is violated. Therefore, this operator must be constructed in a special way (*Nota bene*: one possibility would be that the propensity would be considered as generating a distribution of adaptive preferences to which no probabilities would be associated, which would mean, however, a probability distribution, but only based on a lexicographic ordering ranks, so meaning a distribution of ranks, not of probabilities). Thus, if $\Omega : P \to PA$, then the condition will be checked: $\Omega\left(P^j\right) = \left\{PA_1^j, PA_2^j, \ldots, P_{n_j}^j\right\}$, where with j the propensity of type j was noted).

183 In the case of several tunnels, associated with different adaptive preferences, one could probably identify a tunnel that we can call a *fundamental tunnel* or a *reference tunnel* that would consist of the intersection of all tunnels associated with adaptive preferences generated by a given propensity. The concept of fundamental tunnel is the concept that will connect with the other objectives of the research, namely, with two very important topics: (a) the concept of natural price, which will be correlated with stabilizing adaptive preference, so with its 'location' inside the fundamental tunnel; (b) the use of *interval mathematics* – the fundamental tunnel (which is an interval) will be obtained by operating, through this mathematics, the tunnels associated with each adaptive preference (*Nota bene*: of course, the variation of tunnels, including the fundamental one, is a distinct subject in this examination).

184 The relative subjectivity of the (adaptive) preference must be seen in the same hermeneutical key as in the case of the objectivity of the relative propensity: the individual's preference does not manifest itself (i.e., absolutely) but in SF and CG in which the individual is physically and culturally immersed. In other words, no preference can be manifested except in the concrete context of the SF-CG pair (just as propensity can only be manifested under the dispositional conditions required by Popper and Fetzer, respectively). Therefore, the relativity of adaptive preference is something other than its conditionality, that is, there is no conditional adaptive preference but only relative adaptive preference. As we have suggested elsewhere in the paper, SF and CG function in a 'gravitational' manner (see Figure 3.27), 'attracting' the adaptive preference to manifest around and near them, that is, around and in the proximity of the habitus in which the individual in question is immersed.

185 From a technical point of view, there are several "colors" of noise (so several categories of irrational agents): white noise, black noise, pink noise, among which there are rigorous mathematical relations (especially for the continuous case, through the use of derivatives). We will return to the typology of noise colors.

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Financial market analysis and behaviour: The adaptive preference hypothesis

Annex 1: Analogy in modelling

The concept of analogy can be defined as follows: the result of the *intuitive* (comprehensive) perception of a unit (in the sense of homogeneity), of a certain kind, between a phenomenon-origin (FO) and a phenomenon-destination (FD), where the FO and the FD are not in causal relations between them. The following clarifications should be noted regarding this definition

- the analogy has nothing to do with the intellect (associated with logical, inferential construction) but with intuition (comprehension);
- there are also *pseudo-analogies*: they are the analogies that can be associated, as a last resort, with a causal dependence between *FO* and *FD* ;
- there are also *quasi-analogies:* they are analogies which, although they do not imply causal relations between *FO* and *FD* , however imply structural relations (synchronous relations, of co-existence but not of co-evolution) between *FO* and *FD* ;
- *analogical ability* is directly proportional (perhaps in an exponential dependence) to the depth and sophistication of the background of the cognitive subject who is interested in analogy and makes inquiries in this matter.

There can be five distinct classes of analogies:

Evolutionary Analogy (EA)

- def: two entities of the same kind (either things or properties or relations)[1] are *evolutionary analogous* if one can find an entity that generated (either in time or space) the two entities that, once appeared, acquire predicates (causalities/diachronies or structuralities/synchronies) distinctly breakable[2] between the two entities; for example, negative and positive feedback have a common predicate of sufficienc (the opposite direction of the reaction), so they are *analogous from the evolutionary perspective* of the concept of feedback;
- operational way of establishing the analogy: identification, by intuitive intimation, of a common set of sufficien predicates, simultaneously, with distinct breakable sets of new necessary predicates;

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- identifying formalization:
  - be PS_{FO} list (the set) of predicates of sufficienc of FO; PS_{FD} list (the set) of predicates of sufficienc of FD; PNN_{FO} list (the set) of new predicates necessity of FO; PNN_{FD} list (the set) of new necessity predicates of FD; PN_{FO} list (the set) of the necessity predicates of FO; PN_{FD} list (the set) of necessity predicates of FD;
  - then: $PN_{FO} = PS_{FO} \cup PNN_{FO}$; $PN_{FD} = PS_{FD} \cup PNN_{FD}$; $PS_{FO} \cup PS_{FD} = PS_{FO} = PS_{FD}$; $PS_{FO} \cap PS_{FD} = PS_{FO} = PS_{FD}$; $PNN_{FO} \cap PNN_{FD} = \varnothing$.

Formal Analogy (FA)

- def. 1: by formal criterion we mean that criterion that 'dictates' the structure (internal configuration) of an entity (thing, propert , or relations);
- def. 2: two entities of the same kind (things, or properties, or relations) are *formally analogous* if their abstract structure (independent of materiality or hypostasis) is identical; for example, a segment of reality and the model associated with that segment of reality (such as a system of equations);
- operational way of establishing the analogy: identification, by intuitive intimation, of an identical structure at the two entities, abstracting on the diffe - ences of objectification (or phenomenalization) of these structures.

Nota bene 1: *if this modality is built intellectually, then the analogy disappears, becoming a logical calculation of formal equivalence*

- o illustration 1: quantum wave mechanics (*Schrödinger*) and matrix quantum mechanics (*Heisenberg*);
- o illustration 2: most of the microphysical theories based on strings.

Nota bene 2: formal analogy can also be called *analogy of mechanism*, or *functional analogy*.

Causal Analogy (CA)

- def.: two entities of the same kind (things, or properties, or relations) are *causally analogous* if the causal impact suffered or the causal impact generated is the same for the two entities;
- operational way of establishing the analogy: identification, by intuitive intimation, of morphostasis (different causes lead to the same effect) and of morphogenesis (identical causes lead to different effects)
- types:
  - *morphostasic* causal analogy $MSCA$: different causes lead to the same effect (or to identical or equivalent effects); for example, (on personal

income) a reduction in the tax rate or a reduction in the tax base has the same effect on the amount of tax due. *Nota bene*: therefore, the reduction of the tax rate and the reduction of the tax base are *analogous to the causal morphostasis*;

- *morphogenesic* causal analogy *MGCA* : the same cause (or identical or equivalent causes) leads to different effects; for example, a social aid granted can lead either to the eradication of the cause of eligibility for social aid or to the chronicity (by moral hazard) of the cause of eligibility for social aid. *Nota bene*: therefore, the eradication of the cause of eligibility for social aid and the chronicity of the cause of eligibility for social aid are analogous to morphogenesic causality;

Scale Analogy (SA)

- def.: two entities of the same kind (things, or properties, or relations) are *scalarly analogous* if a change of scale operated on one obtains the other;
- operational way of establishing the analogy: the identification, by intuitive intimation, of the scalability, that is, of the preservation of the identity through scale changes;[3]
- types:
  - fractal scale analogy (*FSA*): the geometric (spatial) shape of an entity is invariant to scale changes; for example, two similar triangles are *fractal* analogous (operating a scale on one will get a triangle congruent with the second). *Nota bene*: so, the two triangles are fractal scale analogous
  - proportional scale analogy (*PSA*): the quantitative value of a composite entity is invariant with changes; def.: a composed entity is an entity that has meaning only by virtue of its hypostasis that integrates two or more entities of the same kind; for example, two ratios of real numbers are proportionally scale analogous if by applying an algebraic operator on one the other is obtained, so the two reports are *proportionally* scale analogous. *Nota bene*: the proportional scale analogy is the basic analogy supported by Aristotle.

Referential Analogy (RA)

- def.: two entities (things, or properties, or relations) are *referential analogous* if the replacement of the referential of one with the referential of the other leaves invariant the entity that suffered the replacement of the referential; *Nota bene*: the referential analogous is specific to notions (concepts) and appears either through terminological inflation (several terms that stand for the same concept) or through terminological inaccuracy (non-perception of the identical referential associated with different terms);
- operational way of establishing the analogy: identificat on, by intuitive intimation, of the identity of the referential in the two entities; e.g., 1.: two

synonymous verbal terms are *referentially analogous*; e.g., 2.: two actions or phenomena exerted on the same entity (or concerning the same entity) are *referentially analogous*;
- illustration: the reduction of the nominal wage and the increase of inflation are two actions (or phenomena) that modify the same entity: the purchasing power, so they are *referentially analogous*.

Annex 2: Brief summary of the probability problem

The historical framework

- (1654) the knight of *Méré* asks *Blaise Pascal* (whom he knew at gambling) to solve the distribution of the pot in an unfinished game between two players. *Nota bene*: in fact, the first formulation of the problem is made by *Luca Pacioli* (1494);
- *Pascal* finds a solution (inventing a complicated recursive method) but consults *Pierre Fermat*, who finds a simpler and, in fact, more appropriate solution. *Nota bene*: it seems that *Pascal* never understood *Fermat*'s method;
- a correct solution: the pot is divided according to the chances of winning that the two have if the game would continue until the end (*Nota bene*: *Pascal* mistakenly believed that the game must stop when one of the players wins and not to exhaust the possibilities of the game);
- problem characteristics:
  - was not really a problem of cognitive uncertainty but rather concerned the system/object;
  - it was a logic of possibilities rather than a logic of chances (i.e., a logic of what might have happened if the game was completed), so the focus was on the system, not the observing subject;
  - it aimed at the ethics of the distribution of advantages based on the logic of possibilities, if the game would have been completed;
  - aimed at *a priori* probabilities (or, in *Bayes*'s terminology, initial probabilities);
- subsequently, probability focused on both the object (frequential or objective probabilities) and the subject (epistemic or subjective probabilities).

The random

(def.) deterministic system: a real (objective or subjective) system whose state at time t_i can be predicted with certainty by considering the law of motion associated with the system's state at time t_{i-1} ($i \in N$).

- *Nota bene*: of course, we also need a law (regularity) that 'governs' the kinematics of that system (the law of 'motion');

- the state at time t_{i-1} is considered to form the *initial conditions* of the kinematics of the system.

(def.) *random* (or stochastic) *system*: a non-deterministic system. Attention! – the deterministic-random classification has nothing to do with causality; regardless of the type of system, causality exists (so random systems are also causal systems).

Characteristics of randomness:

- it refers to the subject, not the object: at the level of the object considered as an event, an event occurs or does not occur (there are no events produced in proportion of 35%!). *Nota bene*: however, if the objects are statements, judgements, or justifications (as in epistemology), there are degrees of occurrence of the objects/occurrences;
- a reference to the subject is of a cognitive nature (epistemic, if necessary) – see *Chaitin*: the stochastic character of a number cannot be demonstrated;
- the randomness consideration is made from the perspective of the degree of knowledge/information held by the subject regarding the object;
- the mathematical study of randomness (of stochasticity) begins with *Richard von Mises* (1981): the study of the collective, collection, and set.

The modern mathematical (including axiomatic) foundations of randomness are laid (in 1960s) by *Kolmogorov and Chaitin*.

- the longer the computer program in treating of a process the more random is that process (*Kolmogorov* complexity);
- *Chaitin*: a numerical process is stochastic if the length of the smallest algorithm describing it is approximately equal, in bits, to the length of the process itself;
- *Nota bene*: *Chaitin* shows that it cannot be proved that a number is stochastic.

There are two standard approaches to random (stochasticity):

- by relation to the *law of large numbers*: convergence in frequency (*Nota bene*: the definition of frequency as the ratio of the number of favourable cases to the number of equally possible cases is a static case, ultra-simplified of the description of the random; rigorous is convergence in frequency);
- by the *betting strategy* (martingale).

Stochasticity and quasi-stochasticity:

- a stochastic (of course, from a cognitive perspective, not ontological) are only natural phenomena (events) (white noise) – for example, Brownian motion and disintegration of elementary particles;

- the other phenomena/processes (in which the subject is involved) produce quasi-stochastic situations, because the process (algorithm) of random production is deterministic;
    - e.g., random walk, *Monte Carlo* method;
    - even if it were random, the algorithm would be designed in a deterministic way and so forth.

Some theoretical problems of the random (stochasticity):

- a system/process is random if no pattern of functioning or behaviour can be associated with it (*Nota bene*: *functioning* refers to the relationship between the components of the system, and *behaviour* refers to the relationship between the system and its environment)
- according to *the principle of insufficient reason* (*Laplace*), when we do not have patterns, the system in question is associated with an equi-probability distribution (see here: (a) *Bayes*, with apriori probabilities; and (b) *Kahneman*, with the basic rate of probability assignment). *Nota bene*: *Laplace*'s formulation of determinism (*Laplace*'s demon) is in his introduction to his own Treatise on Probabilities(!);
- but an equiprobable distribution is inconsistent with the normal distribution (*Nota bene*: although it is called Gaussian, the normal distribution was proposed by *Moivre*; it is true that de *Moivre* based it directly on numerical values, and *Gauss* started from measurement errors on numerical values);
    - so normally distributed processes are stochastic, so they should not be examined with probability theory (if, as is presumed, probabilities concern the random);
    - or, perhaps the probabilities associated with normal distribution do not refer to stochastic process;
    - *Nota bene*: stochasticity is not an ontological property but a gnoseological one;
- *Charlotte Sophie Werndl* (2009) has shown that any stochastic model is, from observational point of view, equivalent to a deterministic one; for example, it has been demonstrated that coin tossing is not a random process, but it can be described (and thus a pattern can be associated to it) by classical mechanics.

Nature and typology of probability

Etymology

- (Latin) *probare* (to prove) and *ilis* (capacity, property): so probability means *an ability/property to be verified* or *proved*, or *the ability/property to be believed*;

- *Nota bene*: in German, semantically, probability means apparent truth (*Wahrscheinlichkeit*).

Interpretations of probability:

the objective interpretation;
the subjective interpretation;
the logical interpretation;
the epistemic interpretation;
the intuitionist interpretation;
the quantum interpretation;
the chance interpretation;
interpretation in terms of possible worlds;
non-orthodox interpretations;
interpretations associated with the notion of infinit .

Objective interpretation

It addresses the probabilities that can be associated with systems (or events in a given system) based on the objective properties of those systems (inter-personally accepted); for example, on the basis of the symmetry of the dice or the coin, or on the basis of the full list of possibilities.

(1) classical probability (generated by the problem *de Méré*):

- $p_f = \frac{N_c^f}{N_c^{ep}}$ (with p_f : classical probability; N_c^f : number of favourable cases; N_c^{ep} : number of *equally possible* cases (either potentially or drawn from an actual archive, historically));
- although this seems to be an objective interpretation, that is, independent of the subject, it turns out to be a subjective interpretation; for example, the phrase 'equally possible' remains unclear (this seems to imply an interpretation of the subject, not a property of the object);
- *Laplace* defined them on the basis of *the principle of insufficient reason*: those cases on which the subject refuses to give them preferential positions (*Nota bene*: so the cognitive appears!);
- the principle of insufficien reason (called by *Keynes* the principle of indiffe - ence) generates paradoxes;
    - some paradoxes have been highlighted by *Bertrand Russell*;
    - we will discuss here the *van Fraassen* paradox, a very conclusive paradox;
- a factory producing boxes (cubes) with dimensions between 0 and 1 m (but not reaching 0 metre or 1 metre);
- two events: (a) the next box produced is between 0 and ½ metre in size; (b) the next box produced is between ½ and 1 metre in size;

- on the basis of *Keynes*'s principle, we give the two events equal probabilities: ½;
- be the following four events: (M) the next box has an area of one side between 0 and ¼ metre, (N) between ¼ and ½, (P) between ½ and ¾; and (Q) between ¾ and 1;
- according to *Keynes*'s principle, each of these events will be given probability of ¼;
- the conflict with the previous assignment of probabilities arises: the event 'with size ½' is the same as the event 'with area ¼', but the two have been assigned different probabilities (½ and ¼, respectively), violating the Keynes principle.

(2) frequential probability:

- was supported by *Richard von Mises, Venn, Reichenbach*;
- does not refer to an individual event but to a large number of events (or to the repetition by a large number of times of an individual event – which is equivalent);
    - on the basis of the law of large numbers, *convergence in frequency* will check p_f from classical probability;
    - for finite referential classes (sets of events), the frequential probability will be expressed by rational numbers (of power $\aleph_0$);
    - experiments can also be done in mind, so with potential frequencies;
    - the problem of the reference class (Venn) arises: how do we form the class of produced cases?
    - hypothetical frequencies (number of trials in which the event occurs, relative to the total number of trials, if the trials were made) were proposed by *von Mises* and *Reichenbach* (Mises, 1981);
- in fact, the limiting frequency (*convergence in frequency*) is determined for an indefinite number of experiments;
- the probability is sensitive to the order in which the hypothetical experiments are performed (*Nota bene*: a kind of sensitivity to initial conditions, which generates chaotic kinematics, although strictly deterministic).

(3) propensive probability:

- arises from the need to associate probabilities to singular events (e.g., in quantum mechanics or in the economic or social field);
    - o proposed by *Karl Popper*: the objective 'inclination' of an individual event to have a certain occurrence;
- so the propensive probability is not a frequency but a tendency, a propensity, an inclination towards a certain occurrence. There are attempts to reconcile

the frequential probability and the propensive probability by considering the *long-term* propensive probability (*D. Gillies*);

- instead of probabilities being the result of sequences of events (leading to frequencies), they are the result of the *conditions of generation of these sequences* (*Nota bene*: this type of probabilities could be used in economics, including by integrating historical sequence rules, i.e., historical sequences – see *Xenopol*);
- in relation to the propensive probability, the *Humphreys paradox* arises: the propensities are not symmetric, but the probabilities should be (if $P(A \mid B)$ is defined, then $P(B \mid A)$ is also defined);
    - in this sense, there are, however, also theories for *a-symmetric probabilities* (e.g., *Rényi*), but *Popper*'s theory is for symmetric probabilities!
    - *Popper* remained at the interpretation of the singular case: it occurs under conditions that concern, however, the whole state of the world (it raises, so, the problem of entanglement or bootstrap arises in the matter of objective probability – our emphasis).

Subjective interpretation

- subjective probability is the information held by the subject about a given system (object);
- representatives: *Philip Koopman*, *Oskar Morgenstern*, *Frank Ramsey*, *John von Neumann*;
- it is the dominant version today in the field of probability theory;
- probabilities are interpreted as degrees of belief (in the sense of trust);
- it usually concerns assertions (e.g., those concerning bets) (*Nota bene*: see Pascal's bet);
- it uses the concept of utility (introduced by *Daniel Bernoulli*);
- there is also an inter-subjective version (proposed by *John Maynard Keynes*): the use of information is based on a system of norms of rationality (so on inter-subjectivity);
- a connection between subjective probability and objective probability has been tried (*David Lewis*): *principal principle*: if objective probability is known, then subjective probability must be equal to it.

(1) Bayesian version of subjective probability:
(1.1) orthodox Bayesianism: refers to the beliefs (degrees of trust) of the subject:

- these beliefs must obey the axioms of probability;
- beliefs will only change when new information emerges;
- updating will be based on *Bayesian conditioning* (Bayes's rule/theorem);
- be set a language $\mathcal{L}$ which is describing belief states;
- an initial belief in the occurrence of event A, C_0 and a subsequent belief, C_1, which is formed as a result of the acquisition of new information, E;

- then, following the orthodox diachronic constraint (ODC), which is a rationality constraint: $C_1(A) = C_0(A \mid E)$;
- *Richard Jeffrey* criticizes the presumption that information E is certain;
  - he develops a variant in which the acquisition of new information is uncertain, which he called *probability kinematics*, but it is known as *Jeffrey conditioning* (JC);
  - (JC) $C_1(A) = C_0(A \mid E) \cdot C_1(E) + C_0\left(A \mid \overline{E}\right) \cdot C_1\left(\overline{E}\right)$ (of course, here one could construct a more general linear combination, using weights for the two terms – our emphasis);
  - current version: $C_1(A) = \sum_i C_0(A \mid E_i) \cdot C_1(E_i)$, where E_i is mutually exclusive and exhaustive on $\mathcal{L}$ (that is, they make a partition on $\mathcal{L}$) (here weights can be used, too – our emphasis);
  - *Nota bene*: it is appreciated that there is still much to be done for the development of an epistemic rationality, which would also develop orthodox Bayesianism.

(1.2) *current* Bayesianism:
subjective Bayesianism:

- some: the only condition is to submit to the calculus of probabilities (so any initial belief is equally rational);
- others: the initial belief must be regular: assign values of 0 or 1 only to probabilities that refer to false judgements, or true ones, respectively; for the other, contingent judgements, they must assign probabilities between 0 and 1 (*Nota bene*: obviously, the aim here is to adopt a fuzzy theory);
- *purpose*: not to assign truth values to contingent statements;
- as information emerges, the probabilities of contingent statements change objective Bayesianism;
- new information does not concern the original belief, so we do not need to place any constraints on it at the outset;
- in most cases, the initial belief assigns probabilities based on the principle of indifference or insufficien reason, which is analogous to the principle of maximum entropy (*Jaynes*), that is, it calls for equi-probability.

(1.3) conditionalities/constraints imposed on current Bayesianism:

- so far, we have three constraints on initial beliefs:
  - to obey the calculus of probabilities;
  - the belief function to change according to the constraints (*Bayes*, *Jeffrey*);
  - to be regular;

- there are other constraining rules:
  - *the principal principle* (*David Lewis*): the initial belief must be consistent with any of the objective probabilities in the world, if they are known;
  - let F_t be the chance of an occurrence at the moment t (e.g., propensity of A occurring);
- (LSC) $C_t\left(A \mid F_t = x \wedge E\right) = x$, where E is a statement that is irrelevant to A, and (LSC) is a (Lewis) *synchronous* constraint;
- *reflection principle* (*van Fraassen*): if, after reflection, the subject has a certainty, then this must be taken over in the initial belief (this is a (van Fraasen) *diachronic* constraint): (FDC) $C_{t_1}\left(A \mid C_{t_2}\left(A\right) = x\right) = x$, where $t_2 > t_1$.

(1.4) probability calculation (*Bayes*):

- the case of probabilities defined on *sets*

$$P\left(A \mid B\right) \cdot P\left(B\right) = P\left(B \mid A\right) \cdot P\left(A\right)$$

$$P\left(A \mid B\right) = \frac{P\left(A \cap B\right)}{P\left(B\right)} = \frac{P\left(A \cap B\right)}{P\left(A \cap B\right) + P\left(C_A \cap B\right)}$$

- the case of probabilities defined on *judgements*
  - let $P\left(I\right)$ the prior probability that hypothesis I be true (or correct)
  - let $P\left(I \mid D\right)$ the posterior probability of hypothesis I, conditioned by the data D
  - let $P\left(D \mid I\right)$ be the probability of finding D if hypothesis I is correct
  - let $P\left(D \mid I_{false}\right)$ be the probability of finding the data D if hypothesis I is false
  - be $P\left(I_{false}\right) = 1 - P\left(I\right)$
  - then $P\left(I \mid D\right) = \dfrac{P\left(I\right) \cdot P\left(D \mid I\right)}{P\left(I\right) \cdot P\left(D \mid I\right) + P\left(I_{false}\right) \cdot P\left(D \mid I_{false}\right)}$

Logical interpretation

- the logical probability is proposed;
- representatives: *John Maynard Keynes*, *William Johnson*, *Rudolf Carnap*;
  - when the conclusion follows partly, not wholly, from premises;
  - $P\left(B \mid A\right) = x$ to be read as: A implies B to the extent of x;
  - one thus hopes for a transfer from logical deduction to logical induction (by generalizing total implication to partial implication). If c is a confi - mation function, then $c\left(A \mid B\right) = P\left(A \mid B\right)$;

- the description is as follows: the number of models in which A and B are true, relative to the number of models in which A is true is x. *Nota bene*: if we replace 'model' with the possible world, then we arrive at the classical definition of probability;
- *Carnap* proposes a purely *syntactic* definition of probability:
    - in a language containing logical predicates and logical constants, introduce state descriptions: maximal specification of the world;
    - if we have M and N logical predicates and m and n logical constants, then a state description is: $(Mm) \wedge (Mn) \wedge (Nn) \wedge (\overline{N}m)$, that is, any state description is a conjunction of predicates in which each predicate (or its negation) is applied to each constant in that language;
    - *Carnap* constructs the probability function as a measure, x, over all state descriptions (a measure he considered to be sometimes unique, sometimes non-unique).

Epistemic interpretation

- refers to the patterns we apply to the world;
    - if the model is deterministic, it does not follow that the modelled reality is deterministic;
    - if the model is stochastic, it does not follow that the modelled reality is stochastic;
    - at least objective probabilities do not express ontological properties but epistemic properties. Sometimes, it is useful to consider the randomness as a property of the world – therefore trans-epistemic (e.g., chaotic systems);
- some chaotic systems are modelled by deterministic equations, but it is useful to consider them as stochastic (*Nota bene*: see *Schrödinger* wave equation);
- other chaotic systems are modelled by stochastic different al equations (see *Black-Scholes-Merton* formulas for pricing financial derivatives);
- *Nota bene*: from an epistemic point of view, any stochastic model is equivalent to a deterministic one (demonstration given by *Charlotte Sophie Werndl*, 2009);
- objective probabilities are not properties of the physical world;
- there are two ways to access the concept of probability:

(1) the derivation, from experience, of probability distributions and the formation of archives of these empirical values (without any assurance that they will work in the future) (*Nota bene*: this way, specific to classical objective probabilities, is therefore based on induction):

- as a result, the problem of induction arises (*Hume*'s problem of causality: he speaks of constant, not frequent, joining of phenomena between which we, by induction, 'decree' causal relations);

- therefore, objective probabilities are a form of Bayesian, that is, subjective, probabilities (*Timothy Williamson* speaks, more precisely, of *Bayesian objectivity*).

(2) assuming of a certain measure of probability (through belief, trust):

- Bayesianism basically refers to an epistemic approach to probability (although it is usually treated as generally subjective probability; within subjectivity, Bayesianism is not mere trust, although the starting point is of the belief type, but is an epistemic adjustment of the initial belief, based on subsequently acquired information/knowledge);
- conditional probabilities are primitive in relation to absolute probabilities (*Nota bene*: see later the primitive-derived relation in the matter of mathematical construction of probability).

Intuitionist interpretation

- proposed by *Brian Weatherson* (2003);
- is a theory of rational beliefs (degrees of belief);
- is considered to resolve some objections to Bayesianism;
- the basis of this theory:
  - there is an agent who believes in A and in $\overline{A}$;
  - these beliefs (their probabilities) are additive;
  - however, the sum of these probabilities is not 1 (the theory does not contain a theorem showing that $P\left(A \vee \overline{A}\right) = P\left(A\right) + P\left(\overline{A}\right) = 1$);
  - *Nota bene*: this implies an omniscient logical agent (similar to the *homo œconomicus* case – our emphasis);
- *Nota bene*: intuitionist probability has obvious similarities with so-called para-consistent logic – *Newton da Costa*.

Quantum interpretation

- is based on non-distributive logic, that is, it does not contain a theorem that shows that $P\left(\left(A \wedge B\right) \vee C\right) = P\left(\left(A \vee C\right) \wedge \left(B \vee C\right)\right)$;
- in classical mechanics we cannot determine common distributions of conjugate variables (e.g., common distributions for position and momentum in the *Heisenberg* indeterminacy); even if one could do that, the joint probability distribution of position and momentum will not be non-negative for all regions of phases space;
- *Nota bene*: it seems that the development of a probability theory specifica ly for quantum mechanics has not yet succeeded;

- the peculiarities of quantum probability;
    - in contexts involving the use of mathematical probability theory, functional is a logic of events or propositions to which probabilities are assigned, not a logic of qualitative statements relating to mathematically formulated theory;
    - the algebra of events requires that each event or element of the algebra be assigned a probability;
    - in quantum mechanics, no probability can be assigned to the conjunction of events, although probabilities can be assigned to each event;
- *Nota bene*: in the *Schrödinger* equation, the square of the amplitude of the wave function represents the probability that the particle whose wave is being described is at a certain location in phases space (see later).

Interpretation in terms of chances

- probabilities reflect knowledge about a physical system, not a property of that system;
- (def.) a process is a chance process if all the knowledge available about it at a given time is sufficien for a rational agent to specify at least two different occurrences of that process in the future but cannot specify with certainty which one will occur. *Nota bene*: rational means verifiability of constraints in the estimation (of time, capacity, etc.);
- there are three types of chance processes:
    - fair processes: when possible occurrences have equal probabilities (equiprobability – according to *Laplace*'s principle of insufficient reason)
    - preferential processes: when one of the occurrences has the highest probability;
    - unknown processes: when nothing is known about the occurrences.

Interpretation in terms of possible worlds

- the question: when an occurrence is actualized, where are the other possible occurrences? (*Nota bene*: analogously to the case of *Schrödinger*'s cat);
- the answer: in other possible worlds, which are close to experience when an occurrence actualizes (*David Lewis*) – for example, collapse of the wave function from the linear superposition state into a given occurrence.

Non-orthodox interpretations

- negative probabilities – *Richard Feynman*;
- imaginary probabilities (based on imaginary numbers) – *Nick Cox*;
- hyper-real (or unlimited) probabilities – *Alfred Rényi*;
- probabilities with interval values – *Isaac Levi*.

Interpretations associated with the notion of infinity

- for infinite sets of events, *Cantor*'s concept of cardinality should be replaced by the concept of *numerosity*;
- *Cantor*'s cardinal numbers:
  - shows that there are infinities greater than other infinities (the infinity of real numbers, of non-countable type $2^{\aleph_0}$, is greater than the infinity of natural numbers, of countable type $\aleph_0$). *Nota bene*: the question remains whether between $\aleph_0$ and $2^{\aleph_0}$, there is any cardinal: this is the problem of the continuum; Cantor answered no (without being able to prove it), and that's why he noted $2^{\aleph_0}$ with $\aleph_1$;
  - the set is infinite if and only if there is a biunivocal correspondence from that set to a sub-set proper to it;
- numerosity:
  - finite sets have two properties:
- if a set is a sub-set of another set, it has a cardinal smaller than the latter if and only if it is a proper sub-set of the set (*Hume*'s principle);
- two sets have the same cardinal if they can be put in biunivocal correspondence (*Euclid*'s principle);
  - for infinite sets, the two principles are inconsistent; one must choose between them;
- *Nota bene*: *Cantor* chose the second;
- others chose the first (*Benci*, *di Nasso*): they called this measure *numerosity*;
- it is related to non-standard analysis (*hyperreal numbers*);
- hyper-real numbers: to the natural numbers is added a number α, called the numerosity of the set of natural numbers;
  - cardinality and numerosity: they are analogous but on different algebras (standard and non-standard, respectively).

Logical construction of probability

In terms of logical reasoning, there are two types of probability:

- absolute probabilities ($P(A)$): they are associated with an event A considered as autonomous;
- relative probabilities ($P(A \mid B)$): they are associated with an event considered non-autonomous, dependent on another (or on others) event/s, B. *Nota bene*: they are also called *conditional probabilities*. The two types of probabilities can be built on each other; the one underlying the calculation of the other is called the *primitive probability*, and the other is called the *derived probability*.

From the point of view of the logical basis for constructing probabilities, they can be constructed:

- on sets (e.g., *Kolmogorov* probability);
- on statements, events, judgements, properties, and relations (e.g., *Popper* probability).

Absolute probability as a primitive

(1) formalization of absolute probability

(1.1) based on sets (*Kolmogorov* formalisation): in bivalent logic:

- describes an algebra on any sub-set of the event field: $\mathcal{F}$;
- *sufficient* condition for algebra: closure to reunion and complementarity;
- *necessary* condition for algebra: closure at intersection. *Nota bene*: so the algebra concerned is also a topology on $\mathcal{F}$;
- on such an algebra, one can define a function (probability function): $P:\mathcal{F}\to\mathbb{R}$, which respects the following axioms:
  - (AK1) $P(A)\geq 0$
  - (AK2) $P(\Omega)=1$
  - (AK3) $P(A\cup B)=P(A)+P(B)$, if $A\cap B=\varnothing$

Nota bene: if $\mathcal{F}$ is infinitely countable (of cardinal $\aleph_0$), (AK3) becomes (AK3'):

$P\left(\bigcup_{i=1}^{\infty}A_i\right)=\sum_{i=1}^{\infty}P(A_i)$, if $A_i\cap A_j=\varnothing$, for $(\forall)i,j$, with $i\neq j$;

  - (AK4) $\sum_{i=1}^{\infty}P(A_i)=1$ (full additivity property)

There are problems with (AK4): it can be shown that there are conceivable cases (e.g., a lottery) in which (AK4) is violated (*Bruno de Finetti*). *Nota bene*: there are also cases of violation of the axiom (AK4) in the case of the association of subjective probabilities (if the husband and wife independently associate probabilities to various household chores, for the same activity usually results a sum of probabilities greater than 1).

(1.2) based on statements, events, judgements, properties, relations: in bivalent logic:

- algebra is replaced by language: $\mathcal{L}$;
- a probability function can be defined: $P:\mathcal{L}\to\mathbb{R}$, so that axioms are accepted:
  - (AP1) $P(A)\geq 0$
  - (AP2) $P(A)=1$, if A_T (that is, A is a tautology)

- (AP3) $P(A \vee B) = P(A) + P(B)$, if A_F (that is, A is not a tautology: $A = \overline{A}_T$)

Nota bene: the case of countable infinity cannot be treated in this case.

(2) formalization of conditional probability (derived from absolute probability)

$$P(A \mid B) = \frac{P(A \wedge B)}{P(B)}, \text{ with condition } P(B) \neq 0$$

Nota bene: however, what do we do if $P(B) = 0$? (see *Emil Borel*'s example, with the point in the Western Hemisphere, conditional on being on the equator): the unconditional probability is ½, but the conditional probability cannot be calculated (since the area of the equator is zero, the probability of being in that area is zero).

Solutions:

- to use instead of real numbers (*Nota bene*: in an infinite field of events, there must be events with probability zero; otherwise it violates (AK4)), in the case of conditional probabilities, hyper-real numbers, or non-standard numbers (*Abraham Robinson*);
  - applying hyper-real numbers to mathematical analysis: non-standard analysis;
  - non-standard analysis is more intuitive than standard analysis (based on real numbers);
- considering the conditional probability as the primitive probability: thus $P(B) = 0$ can be defined (see later)

Nota bene: a hyper-real number is one that is greater than zero but less than any positive real number.

Conditional probability as primitive

(1) formalization of conditional probability

(1.1) based on sets – in bivalent logic:

- let Ω be a non-empty set, $\mathcal{A}$ an algebra on Ω, and $\mathcal{B}$ a sub-set non-empty of $\mathcal{A}$;
  - then, the following axioms lead to the *Rényi probability function*: $P : \mathcal{A} \times \mathcal{B} \to \mathbb{R}$ (CR1) $P(A \mid B) \geq 0$

    (CR2) $P(B \mid B) = 1$

(CR3) $P\left(\left(A_1 \cup A_2\right) \mid B\right) = P\left(A_1 \mid B\right) + P\left(A_2 \mid B\right)$, if $A_1 \cap A_2 = \varnothing$

(CR4) $P\left(\left(A_1 \cap A_2\right) \mid B\right) = P\left(A_1 \mid \left(A_2 \cap B\right)\right) \cdot P\left(A_2 \mid B\right)$

where $A_1, A_2 \in \mathcal{A}$, and $B \in \mathcal{B}$;

- (CR3) generalizes to the infinite countable case:

$$P\left(\bigcup_{i=1}^{\infty}\left(A_i \mid B\right)\right) = \sum_{i=1}^{\infty} P\left(A_i \mid B\right), \text{ with condition } A_i \cap A_j = \varnothing, \text{ for } (\forall) i, j, \text{ with } i \neq j;$$

(1.2) based on statements, events, judgements, properties, relations – in bivalent logic:

- let $\mathcal{P}$ be a set of judgements; if the axioms below are verified, then P is a *Popper probability function*

(CP1) $P\left(A \mid B\right) \geq 0$

(CP2) $P\left(A \mid A\right) = 1$

(CP3) $P\left(A \mid B\right) + P\left(\overline{A} \mid B\right) = 1$, if B is P-normal

(CP4) $P\left(\left(A \wedge B\right) \mid C\right) = P\left(A\right) \mid \left(B \wedge C\right) \cdot P(B \mid C)$

(CP5) $P\left(\left(A \wedge B\right) \mid C\right) \leq P\left(\left(B \wedge A\right) \mid C\right)$

(CP6) $P\left(A \mid \left(B \wedge C\right)\right) \leq P\left(A \mid \left(C \wedge B\right)\right)$

(CP7) $(\exists) D \in \mathcal{P}$, so that D is P-normal;

- B is P-a-normal if $P\left(A \mid B\right) = 1$ for $(\forall) A \in \mathcal{P}$;
- B is P-a-normal if is not P-a-normal.

Nota bene: a-normality here plays the role of falsity in the case of set theory.

(2) formalization of absolute probability (derived from conditional probability): $P\left(A\right) = P\left(A \mid \Omega\right)$.

Quantum probability

- *introductory notions*:
  - *Hilbert space* (*Hilbert*): vector space in which the scalars involved are not real numbers but complex numbers (similar to a complex Euclidean space);
  - *observable in Hilbert (Dirac, von Neumann) space*: an operator (called self-adjoint) that 'stands' in place of a physical quantity;
  - observable has both a discrete and a continuous spectrum;

- *spectrum* of the observable: eigen values (which are real) corresponding to the ortho-normed eigenvectors in the matrix associated with the observable, according to a given basis (in *Hilbert* space);
  - the result of any measurement of the observable is a number from spectrum;
  - the state of a quantum system (e.g., a particle) is given by its wave function;
- the *Schrödinger* wave equation $-\frac{\hbar^2}{2m}\Delta\Psi_n(x)-\frac{e^2}{r}\cdot\Psi_n(x)=E_n\cdot\Psi_n(x)$, where m is the mass of the particle, e is the electric charge of the particle, and Ψ is the wave function of a particle; E_n is the energy of an atom at steady state, and in $\hbar=\frac{h}{2\pi}$, h is the Planck constant;
- the wave function (that is, solution of the wave equation)

$$\Psi(q,t)=e^{-\left(i\cdot E_n\cdot\frac{t}{\hbar}\right)}\cdot\Psi_n(q)$$

where i is the imaginary number ($i^2=-1$); t is the time.
Thus, the wave function describes the time evolution of a quantum system characterized by a given steady state energy;

- *quantum probability*:
  - quantum probability no longer expresses ignorance of the observing subject (as in the non-quantum case) but an intrinsic property of the quantum system (object) of not having a specified position in phases space;
  - thus, we can never know, in principle, not accidentally, the position of a quantum system but only the probability of being in a certain volume of phases space, ΔV, which constitutes a neighbourhood of a given point, x ($x\in\Delta V$);
  - this quantum probability (P_c) is given by the square of the modulus of the wave function. *Nota bene*: the wave function is also called amplitude: $P_c=\left|\Psi(x)\right|^2$. In fact, even less can be calculated, namely, the variation of the quantum probability at the variation of the volume-neighbourhood of point x: $dP_c=\left|\Psi(x)\right|^2\cdot dV$. *Nota bene*: the condition that the total probability is equal to 1 holds also in the quantum domain ($\sum\left|\Psi(x)\right|^2\cdot dV=1$ and $\int\left|\Psi(x)\right|^2\cdot dV=1$);
  - so the wave function becomes a probability amplitude of the position of the quantum system;
  - the development of quantum probability calculus requires some basic notions which, for the time being, have not been treated in this synthesis.

However, in the future, if there is a specific interest, given the unavoidable interferences between economic behaviour and quantum behaviour (e.g., *Heisenberg imprecision* in quantum behaviour can be considered analogous to *free will* in economic behaviour, etc.), the issue of quantum probability could be taken up again at a more detailed and systematic level.

The problem of the common cause

STATEMENT OF THE PROBLEM

- since in economics the ultimate cause is difficul to identify (and often not even necessary, in the sense of useful), the analysis stops at identifying a causal mechanism that establishes only the proximate cause or sometimes a cause immediately prior to the proximate;
- it then becomes important to identify the common cause;

Nota bene 1: the concept of common cause is introduced by *Reichenbach*.
Nota bene 2: (*van Fraassen*) common causes are deterministic (the statement refers to the idea of hidden variables, which appeared in early quantum mechanics).

- (def.) common cause: when between two causally separated events (e.g., spatially separated) a strong correlation appears, it is likely that those events have a common cause;
- *Nota bene*: the concept of common cause is alternatively used as explanatory principle, inferential principle, and principle of rationality (*Wesley Salmon*);
- if A and B are simultaneous, causally separated, and correlated events:

$$P(A \wedge B) \neq P(A) \cdot P(B)$$

- and C is an event prior to A and B, that is:

$$P\left((A \wedge B) \mid C\right) = P(A \mid C) \cdot P(B \mid C)$$

$$P\left((A \wedge B) \mid \overline{C}\right) = P\left(A \mid \overline{C}\right) \cdot P\left(B \mid \overline{C}\right)$$

- then, C is *prima facie* common cause for A and for B, if the correlation between A and B is positive, that is, $P(A \wedge B) > P(A) \cdot P(B)$.

SENTENCES ON THE COMMON CAUSE

1 let events A_i $(i = \overline{1,n})$, such that any two events are correlated with each other. The necessary and sufficien condition for a common cause to be found (constructed) is that A_i admits a common probability distribution compatible with the correlations existing between the events taken two by two;

2 in the case of deterministic correlations, the common cause in sentence (1) can always be constructed in such a way as to have a deterministic character;
3 if symmetry conditions are imposed, then probabilistic correlations will be matched by a probabilistic common cause;
4 (in case of quantum mechanics) in quantum mechanics, there cannot be a common probability distribution as described in sentence (1), so a common cause cannot be constructed (*Nota bene*: so there are no hidden variables).

Probability in economics

PRELIMINARY

- in one way or another, patterns of economic behaviour can be constructed in economics, such as patterns of rationality (e.g., *homo œconomicus*). The existence of behavioural patterns in quantum mechanics (e.g., *Schrödinger*'s wave function) does not negate stochasticity, since this is a stochasticity of the object, not of knowledge about the object;
- consequently, in economics we do not have stochasticity unless we attribute it to the incompleteness or inaccuracy of accepted models of rationality;
    - *Nota bene*: historically, economic theory has advanced precisely by attempting to reduce the incompleteness or inaccuracy of models of rationality in economic behaviour;
    - one of the ingredients not yet sufficientl integrated into models of economic rationality is teleonomy (or teleology): action generated by a-rational purpose;
    - (def.) *a-rational goal*: a goal that is not the consequence of a valid logical inference from a rationality model (the 'orthodox' goal is a rational goal: the result of a valid logical inference from a rationality model);
    - *Nota bene*: *irrational goal* is the goal that is a result of invalid logical inference from a rationality model;
    - teleonomy is the effect of the existence of *free will* of economic 'particles' (individuals acting in an economic sense); (def.) by economic sense is meant the sense that ultimately involves the entropic exchange of the individual with nature.

GENERAL SUGGESTIONS

- paradoxically, in relation to the dominant view, there is no uncertainty in economic field about individual action; each individual has a goal, autonomously, though not independently, of any other individual, and acts in the direction he considers appropriate and sufficient to achieve the goal
- there is, however, uncertainty about the action of other individuals (which is also autonomous but not independent of the action of the individual in question);

- therefore, a certain type of probability will be used (of course, generated exclusively by the only existing category of uncertainty, to which we referred immediately earlier);
- we will call this type of probability: *teleonomic probability* (TP):
  - TP is a *preferential* probability: it has a value of 1 for the event that constitutes the objective of the assumed goal. In fact, TP is not, strictly speaking, a frequential probability, based on information/knowledge about future events. TP is a desirable probability, unrelated to actual (current or anticipated) conditions: for example, the goal may be almost impossible or highly utopian, yet it will be given a probability of 1;
  - true, however, that, as in the case of Bayesian probability (i.e., based on belief or expectation), this probability (let's call it focused probability) can be adjusted towards sub-unit values as the individual acquires new information about the behaviour of other individuals, relevant to the achievement of his goal (e.g., change of a norm);
- focused probability is no longer about truth (e.g., in its truth-correspondence version, valid in Popperian falsification) but simply about *desirability* (in the case of focused probability) or *acceptability* (otherwise);
- probabilities associated with events that do not objectify the goal will have sub-unit values, not necessarily positive (see also *Feynman*'s proposal on probabilities in general, which also accepts probabilities with negative numerical values);
- *Nota bene*: two of the axioms of standard probability theory ($p_i \geq 0$ and $\sum p_i = 1$) will no longer be imposed; instead, the condition $\sum p_i = 0$ will be imposed;
- we propose that the following events be considered:
  - (FE): *the focused event*: nominal achievement, 'without rest', of the prescribed purpose;
  - (RE): *the reversed event*: nominal miss, 'without rest', of the prescribed goal;
  - (AE): *the acceptable event*: nominal achievement of the goal but accompanied by the production of unintended consequences *non-desirable* to the subject;
  - (BE): *the bearable event*: nominal failure to achieve the goal but accompanied by unintended consequences convenient to the subject;
  - *Nota bene*: this 'list' of four possible events in the case of teleonomic probability is useful because it allows the development of an adjacent logic with four 'truth' values (tetra-valent logic);
- a possible (purely illustrative) distribution of teleonomic probability is as follows:

$$\begin{pmatrix} FE & RE & AE & BE \\ 1+x & -x & 3/4 & -3/4 \end{pmatrix}, \text{ with } 0 \leq x \leq 1;$$

- *Nota bene*: of course, these are only a few suggestions; a probabilist could develop, axiomatically, these suggestions and thus construct a theory of teleonomic probability in economics (or, perhaps, more generally, in the social domain).

Miscellanea

- (*Edward Gibbon*): probability is true in general and false in particular;
- probability allows predictability of the mean (*Nota bene*: which, however, is not falsifiable);
- (*Poincaré*): if probabilities are to be rejected, all science must be rejected;
- in evolutionary theory, the concept of fitness is described in probabilistic terms;
- in economics, stochastic differential equations model the variation of quantities;

(*Nota bene*: but this is not what interests us, but rather the variation of behaviour or event)

- two cardinal problems in probability remain unresolved:
  - what is the correct (formal) mathematical theory of them? But that doesn't tell us *what* probabilities are, but rather only *how* they work;
  - what probabilities mean: do they reflect our ignorance or are they ontological?
- in fact, the interpretation of probabilities is equivalent to the philosophy of probabilities;
- (*Jaynes*) used Bayes's formula to formulate the maximum entropy principle;
- in the case of singular events, we can associate *vagueness* (fuzzy logic), not probability (or, at most, Bayesian probability). We need to invent cognitive devices to evaluate the singular event;
- it seems that fuzzy logic can be completely replaced by Bayesian logic;
- rationality theory is intrinsically probabilistic.

Notes

1 As it is known, the Universe contains exclusively these three entities: (a) things, (b) properties, and (c) relations.
2 A distinction between two entities (things, properties, or relations) is crisp if their intersection (from the perspective of set theory) is empty.
3 In reality, the scale analogy is the essence of topology as a discipline of mathematics (more precisely, geometry).

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