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I - Introduction

The aim of the present dissertation is to establish a relationship between the concepts of efficiency and evolution, both applied to Financial Theory.

In section II, the discussion will start by questioning whether evolution, broadly defined, is a subject matter of Finance.

After the initial discussion on Finance’s subject matter, it is necessary to define efficiency and evolution, in order to be capable of establishing any relationship between the concepts of efficiency and evolution. Thus, in section III, several distinct meanings of efficiency will be presented, as well as Andrew Lo’s theory of evolutionary financial markets, which is based on Darwinian evolutionary principles.

Since Lo draws an analogy between Finance and Biology, namely Evolutionary Biology, the main objective of section IV is to understand the limits of recurring to such analogy. The grasp of the limits is made through the consideration of arguments from the Darwinian evolution debate, which has recently been dealing with the analogy. The presentation of the debate is divided into three main topics: the defence of Generalized Darwinism; the arguments against Generalized Darwinism; and Stoelhorst’s Synthesis. The understanding of Stoelhorst’s Synthesis and of the algorithm produced by the generalized Darwinian mechanisms involved will set the path to establish the framework of evolution in a financial market.

Once the generalized Darwinian mechanisms are explained, an investigation on an application of the evolutionary framework to financial markets is presented in sections V and VI.

Conclusions on the relationship between efficiency and evolution are presented in section VII.
II. Finance and the Concept of Evolution

The first question to be answered when treating evolution in a certain domain must be if there is evolution in that domain at all. Therefore, if one wants to study evolution in the financial domain, one must conclude if evolution is a subject matter of Finance. When delimiting the domain of a discipline which is a branch of economic theory, such is Finance, one starts by defining the discipline, in order to verify whether that definition includes the concept one is interested in. In this sense, what one is trying to find is the commitment of that discipline with the concept to be studied, and, in this particular case, the concept of evolution.

Historically, the definition of the economic science has been formulated from two distinct viewpoints: Formalism and the Substantivism. Polanyi (1977, p.19) establishes a distinction between the formalist and the substantivist viewpoints:

“The first meaning, the formal, springs from the logical character of the means-ends relationship, as in economizing or economical; from this meaning springs the scarcity definition of economic. The second, the substantive meaning, points to the elemental fact that human beings, like all other living things, cannot exist for any length of time without a physical environment that sustains them; this is the origin of the substantive definition of economic.”

The most important formalist definition of Economics is by Lionel Robbins (1932; p.16) in his essay on the nature and significance of economic science:

“Economics is the science which studies human behavior as a relationship between ends and scarce means which have alternative uses.”

This definition provides an image of the economic science simply as method. It provides a normative standard and is not realistic. Realistic is here intended to mean that the subject matter of Economics lies not on how economic behaviour ought to be, but how it comes to be, in the real world. In the latter case, then, the emphasis is placed on substance: how the world is and how it changes. Polanyi (1977), correspondingly
defines economic science as an explanatory science – not just a method –, which searches for causes explaining economic behaviour and phenomena.

The textbook definition of Finance proposed by Zvi Bodie and Nobel-prize winner Robert Merton (2000, p.2) is the following:

“Finance is the application of economic principles to decision-making that involves the allocation of money under conditions of uncertainty.”

Recalling the formalism/substantivism distinction, this definition of Finance by Bodie and Merton is primarily formalist, since the emphasis seems to be on calculation of means and ends. However, the authors do not exclude the possibility of a substantive perspective, within Finance, since they include in the domain the way "[I]nvestors allocate their funds among financial assets in order to accomplish their objectives, and businesses and governments raise funds by issuing claims against themselves and then use those funds for operations." Again, there are allocations of funds to attain an end, opening up the possibility of formalist analysis; however, how this allocation actually happens in the financial markets is a substantive issue.

Concerning the possibility of inclusion of evolution in the financial domain, Bodie and Merton (2000) effectively include it – although it is not quite clear which type of evolution – when they argue that “[T]he study of how the financial system evolves over time is an important part of the subject matter of finance.” The latter statement allows the conclusion that evolution makes part of Finance’s scope, at least at a superficial level.
III. Efficiency and Evolution in Financial Markets

Since the discussion on Finance’s subject matter has opened up the possibility of studying evolution in the financial realm, the investigation proceeds with the presentation of the theory of market efficiency and of Andrew Lo’s theory of evolutionary financial markets, in order to set the basis for the analysis of the relationship between efficiency and evolution.

III.1 The Theory of Efficient Capital Markets

The origins of the theory of market efficiency are described in Andrew Lo’s contribution (2004, p. 16):

“As with so many of the ideas of modern economics, the origins of the EMH can be traced back to Paul Samuelson [1965], whose contribution is neatly summarized by his title, “Proof that Properly Anticipated Prices Fluctuate Randomly.” In an informationally efficient market, price changes must be unforecastable if they are properly anticipated, that is, if they fully incorporate the information and expectations of all market participants. Roberts [1967] and Fama [1970] operationalized this hypothesis—summarized in Fama’s well-known description, ‘prices fully reflect all available information’—by placing structure on various information sets available to market participants.”

The theory of market efficiency as described in the excerpt has two major aspects one must scrutinize: the relationship between asset price and information, on the one hand, and the unpredictability of prices, on the other. Both are present in Samuelson (1965) and Fama (1970).

The relationship between asset price and information is that information makes prices change over time, as long as unexpected information reaches market participants. Information, by definition, is always about something and this something, in this financial context of asset price formation, is firms’ capability of generating cash-flows.

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1 EMH stands for Efficient Market Hypothesis.
in the future or increasing the pace at which these cash-flows grow. Positive information increases cash-flow prospects, whereas negative information reduces expected cash-flows. If the transactions of market participants make prices reflect all available information, then the level of efficiency is at an informational level. Thus, the market is called *informationally efficient*.

However, informational efficiency is not sufficient for considering market efficiency in a stronger sense. If market participants reflect information in prices just by buying and selling assets, nothing is said about the levels at which the prices should be. Information being reflected in prices is not the same thing as information being *correctly* reflected in prices. Therefore, a much stronger claim is that market price *correctly* reflects information: Fama (1965a, p.90) presents such a hypothesis by arguing that “an ‘efficient’ market for securities” is “a market where, given the available information, actual prices at every point in time represent very good estimates of intrinsic values”. Thus, a clear definition of intrinsic value is needed, which Fama (1965a, p.36) also provides:

> “Assume that at any point in time there exists, at least implicitly, an intrinsic value for each security. The intrinsic value of a given security depends on the earnings prospects of the company which in turn are related to economic and political factors some of which are peculiar to this company and some of which affect other companies as well”.

The latter excerpt clarifies the implied theory of value in the concept of efficiency: prices reflect intrinsic value, which is an estimate of the cash-flows to be generated in the future. If an asset’s price reflects its intrinsic value, then the market is said to be *fundamentally efficient*, and the intrinsic value is called fundamental value.

The fundamental value of an asset is an equilibrium value: LeRoy (1989, p.1583) argues that “[A]t its most general level, the theory of efficient capital markets is just the theory of competitive equilibrium applied to asset markets”. The value of equilibrium is given by some model of equilibrium and, assuming that the equilibrium is stable, one of its properties is the adjustment of market current price to equilibrium price whenever any external shock occurs. In the context of fundamentally efficient capital markets,
adjustments are corrections of price levels, in response to the appearance of unexpected information. Many agents willing to profit from the new piece of information create a demand or supply pressure in the market until price converges to an equilibrium value. If price equals a theoretical value ‘x’ at any moment in time and the new theoretical value is ‘y’, according to a new piece of information aggregated to the existent set, then the agents pressure market price until it equals or approximates ‘y’. The claim that adjustments must occur in an efficient market are present in Fama et al (1969, p.1), in which an efficient market is “a market that adjusts rapidly to new information”, and in Fama (1965b, p.56), in which “competition will cause the full effects of new information on intrinsic values to be reflected ‘instantaneously’ in actual prices”.

Accordingly, the concept of efficiency to be used to establish the relationship between efficiency and evolution is, then, the following: an efficient market is one wherein asset prices correctly reflect all available information; individual asset prices equal or approximate their own fundamental value; a rapid adjustment occurs if they do not, correcting current prices.

Recalling the unpredictability of prices, it is an implication of continuous market adjustments, which is noted in Andrew Lo’s contribution (2004, p.16):

“The more efficient the market, the more random the sequence of price changes generated by such a market; and the most efficient market of all is a market in which price changes are completely random and unpredictable. This is not an accident of nature, but is in fact the direct result of many active market participants attempting to profit from their information.”

The argument supporting the existence of an adjustment mechanism is, then, that market participants who have new information not reflected in prices transact in the market expecting to profit with that piece of information. These market participants are often called arbitrageurs, since they exploit momentary inefficiencies – arbitrage opportunities –, given by new information not yet reflected in market price. Their continuous action pressures market price to converge to an efficient level. Therefore, the active participation of arbitrageurs eliminates arbitrage opportunities.
It is important, though, to define what arbitrage is. The definition of arbitrage, given by Shleifer e Vishny (1997) states arbitrage as a strategy in which there are two (or more) simultaneous transactions, which combined allow the elimination of risk and the absence of capital. Such definition is determinant when considering arbitrage in a strict sense. However, adjustments are not needed to be arbitrage in this strict sense; the simultaneous transactions are sufficient but not necessary to ensure adjustments towards equilibrium. In order to have an adjustment of market price, in which it converges to fundamental value, it is necessary and sufficient that agents transact – simply buy or sell – in the market until price reaches its efficient level. In this sense, it is not necessary that agents make a risk-free no-capital strategy, which is a sophisticated type of strategy, only attainable by a few institutionalized investors. If one wants to call the simple strategy of buying and selling in the market arbitrage, then it is possible to employ the concept of arbitrage in wider sense, whereby one simply means that simple transactions as buying and selling will force price to converge to fundamental value.

III.2 Problems of the Theory of Efficient Capital Markets

Since Andrew Lo’s theory of evolutionary capital markets is better understood considering the grounds in which it was formed, before presenting the framework of evolution, some problems attributed to the theory of efficient markets are exposed.

Consider Fama’s words in his seminal paper of 1970, portraying the image of efficiency prevalent in that decade:

“(…) consider a market in which (i) there are no transactions costs in trading securities, (ii) all available information is costlessly available to all market participants, and (iii) all agree on the implications of current information for the current price and distributions of future prices of each security. In such a market, the current price of a security obviously "fully reflects" all available information.” (Fama, 1970, p.387)

One concludes that if there are little or no frictions in the market, the latter is efficient. However, the concept of efficiency raises a paradox – the paradox of efficiency –, in which the perfection of the market in aggregating information implicates
no incentives to collect and incorporate information. Assuming that information is costly, if prices reflect all information, there are no incentives to collect it and, then, the market cannot be reflecting all it, since nobody is collecting it: thus, the market cannot be efficient. This is what Grossman (1976, p. 574) states:

“When a price system is a perfect aggregator of information it removes private incentives to collect information. If information is costly, there must be noise in the price system so that traders can earn a return on information gathering. If there is no noise and information is costly, then a perfect competitive market will break down because no equilibrium exists where information collectors earn a return on their information, and no equilibrium exists where no one collects information. The latter part follows from the fact that if no one collects information then there is an incentive for a given individual to collect costly information because he does not affect the equilibrium price. When many individuals attempt to earn a return on information collection, the equilibrium price is affected and it perfectly aggregates their information. This provides an incentive for individuals to stop collecting information.”

The inconsistency is formulated in terms of arbitrage profits in Grossman and Stiglitz (1980, p.393):

“If competitive equilibrium is defined as a situation in which prices are such that all arbitrage profits are eliminated, is it possible that a competitive economy always be in equilibrium? Clearly not, for then those who arbitrage make no (private) return from their (privately) costly activity. Hence the assumptions that all markets, including that for information, are always in equilibrium and always perfectly arbitrage are inconsistent when arbitrage is costly.”

A reformulation of the concept of efficiency (Fama, 1991, p. 1575) followed the objections to market efficiency when information is costly:

“I take the market efficiency hypothesis to be the simple statement that security prices fully reflect all available information. A precondition for this strong version of
the hypothesis is that information and trading costs, the costs of getting prices to reflect information, are always 0 (Grossman and Stiglitz (1980)). A weaker and economically more sensible version of the efficiency hypothesis says that prices reflect information to the point where the marginal benefits of acting on information (the profits to be made) do not exceed the marginal costs (Jensen (1978)).”

The reformulation states that the absence of costs ensures market efficiency. However, if information is costless, every agent collects all information; if every agent possesses all information, each of them knows who gains or loses with trading; since no one is willing to lose money, no agent is able to find a trader: thus, trade does not take place. This latter objection to efficiency takes its form as ‘no trade’ theorems, which are presented in a later section, when necessary.

One assumption of the theory of market efficiency is that “all agree on the implications of current information for the current price and distributions of future prices of each security” (Fama, 1970, p.387). Behavioural Finance’s research program criticizes this assumption, emphasizing that agents have behavioural biases reflected in their actions. Andrew Lo (2004, p. 17) summarizes these biases:

“The standard approach to modeling preferences is to assert that investors optimize additive time-separable expected utility functions from certain parametric families, e.g., constant relative risk aversion. Psychologists and experimental economists have documented a number of departures from this paradigm, though, in the form of specific behavioral biases that are endemic in human decision-making under uncertainty, and several of these lead to undesirable outcomes for an individual’s economic welfare. They include: overconfidence (Fischoff and Slovic [1980]; Barber and Odean [2001]; Gervais and Odean [2001]), overreaction (De Bondt and Thaler [1986]), loss aversion (Kahneman and Tversky [1979]; Shefrin and Statman [1985]; Odean [1998]), herding (Huberman and Regev [2001]), psychological accounting (Tversky and Kahneman [1981]), miscalibration of probabilities (Lichtenstein, Fischoff, and Phillips [1982]), hyperbolic discounting (Laibson [1997]), and regret (Bell [1982]; Clarke, Krase, and Statman [1994]). These critics of the EMH argue that investors are often if not always irrational, exhibiting predictable and financially ruinous behavior.”
An exhaustive study of these biases is not necessary here. It suffices to accept that such non-random behavioural biases exist. If agents have behavioural biases, prices also reflect them, besides information. One may argue that there are sophisticated agents, portrayed as ‘rational’, who make prices converge to fundamental values, if biased agents create inefficiencies. However, if all agents have non-random biases, prices reflect them and inefficiencies subsist. Assuming there are sophisticated agents, who are significantly different from the biased ones, prices may still not converge to fundamental values, if there are limits to arbitrage: even if there are agents making price converge to a fundamental value, if limits to this convergence are observed, then it may not happen. Shleifer and Vishny (1997) argue that, in practice, arbitrage is hard to implement because it is risky and expensive. Barberis and Thaler (2003) and Gromb (2010) point out that arbitrageurs face fundamental and non-fundamental risk, high implementation costs (such as margins) and limits to leveraging. From Brav and Heaton’s (2003) proposal of market indeterminacy, one may derive a further limit: model indeterminacy. The models of valuation one can use to estimate the value of an asset are so many that arbitrageurs face difficulties choosing the most appropriate one.

III.3 The Theory of Evolutionary Capital Markets

The theoretical model proposed by Andrew Lo (2004) breaks with the paradigm of efficient markets, searching for another concept or framework of efficiency. Accepting as building blocks that agents have characteristics which differ from the paradigmatic maximizing behaviour, the point of departure is the concept of bounded rationality of Herbert Simon (1955), in which agents are supposed to satisfice their interest, instead of maximizing it. Starting from this point, the theory asserts that, contrarily to the maximizing behaviour, the solutions to satisficing problems are not analytically defined, but rather found through trial and error. This experimental process associated with the behaviour of agents is the fundamental insight connecting the theory with the possibility of adaptive behaviour, which supposes the development of heuristics suitable to the environment. Consider the following excerpt, in which Lo (2004, p.22) provides an explanation on the evolutionary mechanisms underlying his perspective:
“An evolutionary perspective provides the missing ingredient in Simon’s framework. The proper response to the question of how individuals determine the point at which their optimizing behavior is satisfactory is this: Such points are determined not analytically, but through trial and error and, of course, natural selection. Individuals make choices based on past experience and their best guess as to what might be optimal, and they learn by receiving positive or negative reinforcement from the outcomes. If they receive no such reinforcement, they do not learn. In this fashion, individuals develop heuristics to solve various economic challenges, and as long as those challenges remain stable, the heuristics will eventually adapt to yield approximately optimal solutions to them.”

Lo (2004) notably argues that the continuous activity under stable environment would consistently lead to solutions to the confronted economic (financial) problems that could come close to the optimal solution of these problems. Not only is the stability of environment necessary to develop this adaptive behaviour, but also that the interaction with environment provides feedback, so that agents might learn. If such learning is not possible, then adaptation does not occur. Moreover, if the environment keeps changing rapidly, heuristics will inevitably turn into inefficient behaviour. In this case, the appearance of behavioural biases and associated anomalies is justified: “If, on the other hand, the environment changes, it should come as no surprise that the heuristics of the old environment are not necessarily well suited to the new. In such cases we observe “behavioural biases” – actions that are apparently ill advised in the context in which we observe them. But rather than labelling such behaviour irrational, we should recognize that suboptimal behaviour is not unlikely when we take heuristics out of their evolutionary context. A more accurate term for such behaviour might be ‘maladaptive.’”(Lo, 2004, p. 22). Simon’s metaphor of a pair of scissors underlines the importance of considering human agency and environmental conditions simultaneously. Gigerenzer and Selten (2002, p.4) give an insightful explanation of this metaphor:

“Herbert Simon, who coined the term ‘bounded rationality’, used the metaphor of a pair of scissors, where one blade is the ‘cognitive limitations’ of actual humans and the
other the ‘structure of environment.’ Minds with limited time, knowledge, and other resources can be nevertheless successful by exploiting structures in their environments. In Simon’s (1956) words, ‘a great deal can be learned about rational decision making… by taking account of the fact that the environments to which it must adapt possess properties that permit further simplification of its choice mechanisms’ (p.129). Studying only one blade is not enough; it takes both for the scissors to cut.”

Lo (2004) uses Simon’s notion of bounded rationality and his Satisficing Theory as a starting point for establishing a framework for analysing financial markets:

“By coupling Simon’s notion of bounded rationality and satisficing with evolutionary dynamics, many other aspects of economic behavior can also be derived. Competition, cooperation, market-making behavior, general equilibrium, and disequilibrium dynamics are all adaptations designed to address certain environmental challenges for the human species, and by viewing them through the lens of evolutionary biology, we can better understand the apparent contradictions between the EMH and the presence and persistence of behavioural biases. Specifically, the Adaptive Markets Hypothesis can be viewed as a new version of the EMH, derived from evolutionary principles. Prices reflect as much information as dictated by the combination of environmental conditions and the number and nature of ‘species’ in the economy or, to use a more appropriate biological term, the ecology.”

The statement that markets in the economic and financial domain can be viewed through the ‘lens of evolutionary biology’ raises an unavoidable question on the nature of the comparison between the economic and the biological realm: is the application of evolutionary principles originating in Biology to other domains such as Economics a matter of analogy or ontology? In other words, is the substance of the subject matter Economics somehow comparable to the substance of the subject matter of Biology?

Since Lo draws an analogy between Finance and Evolutionary Biology, the aim of the next chapter is to understand the limits of recurring to such analogy. The grasp of the limits is made through the consideration of arguments from the Generalized Darwinism debate, which has recently been dealing with the analogy.
IV – The Generalized Darwinism Debate

Generalized Darwinism is a theory proclaiming the universal application of Darwinian evolutionary principles to several other domains, besides Biology, in order to explain evolution.

The debate on Generalized Darwinism is here divided into three distinct parts: (1) the defence of Generalized Darwinism; (2) the arguments against Generalized Darwinism; and (3) Stoelhorst’s synthesis.

IV.1 – Darwinism

In order to understand correctly what Generalized Darwinism stands for, a closer look at Darwinism’s basic principles is necessary. The first aspect to be underlined is that Darwin’s theory of evolution (1859) is a conceptual framework partitioned into five theories, each one explaining a specific part of the whole evolutionary process in the biological realm. Mayr (1991, p. 36f) presents these theories as follows:

“(1) Evolution as such. This is the theory that the world is not constant nor recently created nor perpetually cycling but rather is steadily changing and that organisms are transformed in time.

(2) Common descent. This is the theory that every group of organism descended from a common ancestor and that all groups of organisms, including animals, plants, and microorganisms, ultimately go back to a single origin of life on earth.

(3) Multiplication of species. This theory explains the origin of the enormous organic diversity. It postulates that species multiply, either by splitting into daughter species or by “budding,” that is, by the establishment of geographically isolated founder populations that evolve into new species.

(4) Gradualism. According to this theory, evolutionary change takes place through the gradual change of populations and not by the sudden (saltational) production of new individuals that represent a new type.

(5) Natural selection. According to this theory, evolutionary change comes about through the abundant production of genetic variation in every generation. The relatively
few individuals who survive, owing to a particularly well-adapted combination of inheritable characters, give rise to the next generation.”

The emphasis of the Darwinian debate has been placed on this last point, concerning the selection of given characteristics representing variety.

Variety exists in a population, because organisms, which constitute the population, have different characteristics, which condition the way organisms are and behave. Organisms are called interactors, since they interact with their environment and with each other. Characteristics may be inherited or acquired by organisms. Genes are inherited characteristics, and are called replicators, because they are “entities that pass on their structure intact through successive replications” (Vromen, 2008, p.6). An organism passes on characteristics to its descendents by means of sexual reproduction. Retention mechanism ensures the replication of genes. Nonetheless, characteristics may also be acquired during life: although acquired characteristics are not transmitted through sexual reproduction, they also condition organisms’ behaviour.

Variation mechanism is the mechanism that ensures the continuous increase of variety in the natural system: the combination and recombination of genes allow for the replenishment of variety and the appearance of new sets of genes in daughter organisms. Contrarily, the mechanism responsible for reductions in variety is selection mechanism: only organisms fit to environmental requirements survive.

Several authors have claimed that variation, retention and selection mechanisms can be used to explain all evolutionary processes (Hodgson, 2002, 2004; Hodgson and Knudson, 2006; Stoelhorst, 2005; Stoelhorst and Hensgens, 2006). However, there are authors who stand against the applicability of those mechanisms, insisting that the mechanisms involved in Darwin’s explanatory framework cannot capture the cultural mechanisms underlying socio-economic evolution and that the use of Darwinian language is a misleading analogy (Buenstorf, 2006; Cordes, 2006; Nelson, 2006; Witt, 2004).
IV.2 – Generalized Darwinism

Generalized Darwinism is a core set of principles originating from Darwin (1859), explaining evolution in the biological realm which can be applied to other domains. The strong hypothesis is in fact that if there is evolution and if this evolution respects a determined number of aspects, then evolution is explainable by the Darwinian framework. But what is this Darwinian framework? And how must the domain be so that it might be Darwinian explainable?

The application to different domains presupposes a generalization of the set of principles of Darwinian tradition, based on the abstraction of the narrowly-defined scope of those same principles, in order to avoid biological reductionism. Hodgson (2002, p. 260) strongly supports this position, arguing that “Darwinism involves a general theory of the evolution of all open, complex systems.” Furthermore, the generalized core theory also needs domain-specific mechanisms to grasp the phenomena to be explained:

“Universal Darwinism’ is not a version of biological reductionism or ‘biological imperialism’ where an attempt is made to explain everything in biological terms. On the contrary, Universal Darwinism upholds that there is a core set of Darwinian principles that, along with auxiliary explanations specific to each scientific domain, may apply to a wide range of phenomena.”2 (Hodgson 2002, p.270, italics in the original)

Moreover, Hodgson and Knudsen (2006, p.17) assert that “[D]arwinism is unavoidable but this does not mean that the core Darwinian theory is sufficient to explain the processes of social evolution.” As Hodgson and Knudsen (2004, p.) argue, “[D]arwinian principles apply by virtue of the existence of variety, inheritance and selection.” Summarily, Hodgson and Knudsen (2006, p.17) explain why Darwinism principles must be involved in an “adequate explanation of the evolution” and when they are applicable:

2 Generalized Darwinism was called Universal Darwinism, before the name has been changed by the discussants of the debate. The original term – Universal Darwinism – was coined by Richard Dawkins (1983).
“In sum, a complex population system involves populations of non-identical (intentional or non-intentional) entities that face locally scarce resources and problems of survival. Some adaptive solutions to such problems are retained through time and may be passed to other entities. Examples of populations in such systems are plentiful both in nature and in human society. They include ever biological species, from amoebas to humans. They would include self-replicating automata, of the type discussed by von Neumann (1966). In addition, and importantly for the social scientist, they include human institutions, as long as institutions may be regarded as cohesive entities having some capacity for the retention and replication of problem solutions. Such institutions would include business firms. Having sketched in broad terms the type of ‘evolutionary’ system we are considering, we now come to the crucial step in the argument: an adequate explanation of the evolution of such a system must involve the three Darwinian principles of variation, inheritance and selection. These are the broad Darwinian theoretical requirements. They do not themselves provide all the necessary details, but nevertheless they must be honored. Otherwise the explanation of the evolution will be inadequate.” (Hodgson and Knudsen, 2006, p.4)

Hodgson and Knudsen (2006, p.16) state that “as long as we are addressing a population of replicating entities, then social evolution must be Darwinian, whether or not self-organization, human intentionality, or Lamarckian inheritance are involved. As long as there is a population of replicating entities with varying capacities to survive, then Darwinian evolution will occur.” Hodgson and Knudson (2004) suggest that in the economic realm habits and routines are replicators and firms are interactors. They define routines “as organizational dispositions to energise conditional patterns of behaviour within an organized group of individuals, involving sequential responses to cues. Just as habits are elements of human learning and cognition, the building and replication of routines involves organizational learning and the transmission of knowledge. Routines are nevertheless manifestations of human cognition and the interactions of individual minds. To understand how routines work, and the particular role of behavioural cues, it is necessary to consider how any tacit or other information associated with a routine is preserved and replicated.”(Hodgson and Knudson, 2004,
Nonetheless, Hodgson and Knudson (2004, p.) argue that “Routines are not behaviour; they are stored behavioural capacities or capabilities.”

**IV.3 – Arguments against Generalized Darwinism**

The first major argument against Generalized Darwinism is that the retention mechanism in the cultural domain is essentially different from inheritance in the natural domain. Cordes (2006, p. 535) argues that “there is no direct analogy to the gene – the replicator in the biological realm – in the socio-economic sphere. It has not been possibly to identify anything akin to a ‘social DNA’. In addition, there is no cultural entity that actively replicates itself as does DNA. On the contrary, in cultural transmission the active part is on the subject that disseminates or perceives information.” The inexistence of replicators similar to genes undermines not only the possibility of perfect copies but also the presence of a straightforward and narrowly defined mechanism to explain retention in the cultural domain.

Another important argument is that variation in the cultural domain is driven, as opposed to blind variation, which occurs in the biological domain, what supports for the existence of Lamarckian rather than Darwinian evolution (Penrose 1952; Nelson and Winter 1982). As Stoelhorst (2008, p. 351) explains, “The distinguishing features of Lamarck’s theory of biological evolution are directed variation and the inheritance of acquired characteristics. This is not the way that variations come about and are passed on in nature. In biology variation is random, which is to say that it is blind to the selection pressures that the organism faces, and adaptations developed during an organism’s lifetime cannot be passed on to offspring.” The term “random” means that variation does not occur as a response to an organism’s needs or wants (see Mayr 1991, p. 143). Cordes (2006, p. 533) also sustains this position arguing that “There are no such things as sexual reproduction, mutation, or speciation in cultural evolution” and that “Novel artefacts or ideas are not generated randomly; they are the result of conscious design or of deliberately conducted search for novelty”. This argument may be called the argument of human intentionality, which follows from the “unique human capability both for analytic thinking and for language.” (Nelson, 2006, p. 499).
Human purposeful action implicates that the mechanisms of variation and selection are not independent: the causes of genetic variations, in the biological realm, are independent of the causes of natural selection; however, in the cultural realm, human purpose is determinant in the appearance of novelty, because this novelty is a “design” reflecting human’s needs and wants (Cordes, 2006). Simply put, the necessity of facing selection leads human agents to intentionally develop characteristics, which are favourable. Nelson (Nelson 2006, p.501), recalling this connection between selection and variation, puts it as follows: “the individuals, organizations, groups, that at any time hold particular beliefs or practices are not locked into them, as biological entities are to their genes, but can change them. Thus the relative importance of cultural traits can change, without any change in the population of the society to which that cultural pertains.” The change that is implied is a reflection of responding to selection through variation of the traits.

Cordes (2006, pp. 536-537) points out that “a prerequisite for natural selection to produce systematic change is a certain degree of inertia on the part of the environment and the unit of selection”. However, in cultural evolution, selection may not be as inert as in biological evolution, considering the fact that human purpose might influence the reaction to selection as well as cause development of pre-selection reflexes. This pre-selection is exposed by Nelson (2006, p.499), where he says that “the new things that are tried in practice have been subject to a considerable amount of scrutiny before they actually are put into practice”. Note that “in cultural evolution a good portion of the relevant variation is in human minds, and explored through calculation, discussion, and argument, rather than in actual practice” what implicates that “the actual variation at any time is a small portion of the contemplated variation, and an important part of the selection process involves the winnowing of alternative ideas for action before final action is taken” (ibid). What this means is that selection starts in humans’ minds before it might be felt by an external mechanism.

Furthermore, Nelson (2006) presents what he calls (the) “three major (overlapping) reasons”. In his words, firstly, “for many areas of cultural evolution, the survival of the individuals and organizations involved simply is not at stake. Thus there often is no clear analogy in cultural evolution to the mechanisms involving fitness of phenotype in biological evolution.” (Nelson 2006, p.501). In cultural evolution, the ‘unfit’ behaviour
does not cause the death of the agent whose behaviour is inadequate to environment. This argument will henceforth be called the survival argument.

The second reason has to do with the fact that organisms cannot choose or modify any of their genes, in order to become adapted to environment. Again, selection should be independent – it is argued – from variation mechanism, which it is not, in the social domain.

Purposeful actions that take place in cultural environment influence the way environment comes to be. Nelson (ibid) argues that, “while not over playing the role of conscious decision-making, in a wide range of circumstances beliefs about the value, and efficacy, of a particular cultural trait strongly influence whether that trait is adopted, retained, or abandoned. And discussion, argument, persuasion, in some cases coercion, may be a central part of the selection process”. This is Nelson’s third major reason and it is fundamental to understand that the fact that human purpose exists makes a two-way selection mechanism possible. This means that, while selection occurs and agents may deliberately avoid selection and become adapted to environmental requirements, human action also influence the frames in which selection comes to occur.

**IV.4 – Stoelhorst’s Synthesis**

Stoelhorst (2008, p.343) summarizes the debate until his contribution as follows:

“While biological evolution has long been seen as a useful metaphor and source of analogies for the development of theories in economics, there has recently been a lively interest in how insights from biological evolution can strengthen the ontological foundations of evolutionary economics (Dopfer 2004; Dopfer and Potts 2004; Hodgson 2002, 2004; Hodgson and Knudsen 2006; Klaes 2004; Vromen 2004; Witt 2003, 2004, 2006). One of the specific questions that are currently being explored is if theories of economic evolution can be grounded in a generalized version of Darwinism. The answers that have been given to this question differ markedly. On the one hand, advocates of generalized Darwinism claim that Darwin’s theory of biological evolution represents a general logic that can be applied to all evolutionary processes (Hodgson 2002, 2004; Hodgson and Knudsen 2006; Stoelhorst 2005; Stoelhorst and
Hensgens2007). On the other hand, critics hold that Darwinism cannot capture the cultural mechanisms that drive economic evolution and that its generalization amounts to no more than a possibly misleading analogy construction (Buenstorf 2006; Cordes 2006; Nelson 2006; Witt 2003, 2004).

Stoelhorst’s contribution is argued here to be a synthesis, because he accepts both the generalization of Darwinism and the arguments against biological reductionism. He takes Generalized Darwinism’s framework to be nothing more than “a universal, substrate neutral, algorithm to explain adaptive complexity (Dennet 1995).” (Stoelhorst, 2008, p.347). If, on the one hand, Generalized Darwinism is allowed to be ‘universal’, that is, applicable to several domains, on the other hand, it is ‘substrate neutral’, meaning that Generalized Darwinism’s framework is not consigned to any particular domain, be it Biology or Economics. As Stoelhorst takes the framework to be ‘substrate neutral’, he is able to accept the arguments against Generalized Darwinism presented in the previous section and still defend a general application of the Darwinian principles to other domains, without entering in contradiction. He accepts that the particular mechanisms of variation, retention and selection developed in the context of Biology do not apply to Economics. However, since the general mechanisms to be applied to any domain are ‘substrate neutral’, differences between the particular mechanisms in Biology and Economics are irrelevant. Mechanisms applied to Biology are just a particular case of the general mechanisms also applicable to several other domains, which are certainly different from the particular mechanisms from these latter domains.

The statement that the principles consist in an algorithm to explain adaptation is perhaps the most telling to understand what Stoelhorst claims to be the possible contribution of the Darwinian framework of evolution: the author is focused in the *explananda* of the framework, that is, “what the theory of natural selection is able to explain” (ibid). Moreover, “what the Darwinian algorithm explains is variety from common origins, adaptive fit, and the accumulation of design (cf Dennet 1995).” (ibid). If Generalized Darwinism is to be applied to any domain, it is because what is to be explainable in that domain is ‘adaptive fit’, regardless of the particular ‘substance’ of the ‘adaptive fit’.
On the other hand, it is clear that Stoelhorst (2008) does not neglect the *explanantia* of the theory, that is, the framework of explanation: this framework – he argues – is unique, and it is not solely the mechanisms such as variation, retention and selection, but most importantly it is the combination of these, which leads to adaptive fit and adaptive complexity. These latter concepts of adaptation are better understood through the lens of a functional perspective, which Stoelhorst (2008, p.348) presents, following Elster (1979, 1983):

“A behavioral pattern X is explained by its function Y for system Z if and only if:

(1) Y is an effect of X;
(2) Y is beneficial for Z;
(3) Y maintains X by a causal feedback loop passing through Z.”

Premises (1) and (2) are internally connected with the existence of a variety of characteristics (of some entities) that imply behavioural patterns of the type X, whereby X has a function Y, which has itself some benefit within the environment in which the entity possessing X is interacting, that is, the system Z. Premise (3) explains how the system or environmental conditions transform the existing entities: a feedback loop exists, which Stoelhorst (ibid) argues to be selection mechanism, allowing for alterations of the behavioural patterns verified, by selecting “those that work best in the system’s local environment”. Stoelhorst (2008, p.350, italics in the original) generalizes this selection to be a mechanism that “*reduces the variety in a set of entities as a function of the characteristics of these entities.*”

It has been argued that it is the combination of mechanisms that produces the relevant explanatory logic and not the use of isolated mechanisms. Stoelhorst (2008, p. 349) makes his case very clear:

“However, only the combination of selection with a source of variation and retention can fully explain how adaptive fit comes about over time. Without a mechanism to replenish the set of body plans in a way that provides the necessary variation for selection to act upon, adaptations would not result. To consider the alternatives where one of the mechanisms is missing, assume a population of entities. In the case of a
selection and retention mechanism without a source of variation, we have a system where unsuccessful entities get weeded out and successful ones are retained. In a stable environment, this may lead to adaptive fit. If we have a set of apples and, for instance, blemished are selected out, we may end up with a set of apples that fit a selection environment favoring unblemished apples. However, lacking a mechanism to introduce new variations, such an algorithm cannot explain the evolution of variety from common origins, or the accumulation of adaptive complexity. Moreover, as soon as we allow the selection pressure to change over time, even the explanation of adaptive fit breaks down. When, for instance, the selection criterion changes to the color of the apples and only red apples are favored, then, assuming that there is variety in the color of the apples within the set of unblemished apples, the only effect can be a further trimming of the set. In the limit, an algorithm consisting of a selection and retention mechanism without a mechanism to replenish variety can therefore only result in an empty set.

Next, consider the case of a variation and retention mechanism without selection. Here we have a situation where ‘everything goes’. Every variation that comes about is retained because there is no selection pressure. In the limit, this algorithm can only lead to an infinite set. Moreover, in the absence of selection pressure, the resulting set will be largely uninteresting because it will be dominated by entities that are not at all functional. Finally, consider the case of a variation and selection mechanism without retention. This amounts to a system without memory. Variation is generated completely haphazardly, rather than being informed by past success. Because success in environmental interaction is purely a matter of chance, in the limit such an algorithm will result in an empty set. Moreover, an algorithm consisting of only variation and selection cannot evolve any sort of complexity. Without a feedback loop to selective retained information about what works, there can be no accumulation of design.”

Following this thorough explanation of the undeniable importance of the combinatorial feature of the mechanisms, a generalized notion of variation and retention mechanism is necessary, in order to complete the framework of Generalized Darwinism proposed by Stoelhorst (2008). Stoelhorst (2008, p.351, italics in the original) defines variation simply to be a mechanism that “increases variety in the characteristics of the entities of the set”. Inheritance is presented as follows: “an inheritance mechanism
maintains the characteristics favored by selection in the set of entities” (Stoelhorst, 2008, p. 353, italics in the original).

With regard to the question of intentionality, Stoelhorst (2008, p. 353) asserts:

“Each of these mechanisms is a necessary condition for the evolution of adaptive fit. Their combination is a sufficient condition. Darwinian mechanisms can take many different forms without affecting the ability of the Darwinian algorithm to explain adaptive fit. Selection can be an effect of competition for scarce resources or involve a selecting agent. Variation may be random or directed. And the retention of favored characteristics need not involve inheritance or replicators. Injecting a dose of intentionality into any one of the mechanisms only makes the evolution of adaptive fit more likely.”

The contribution of the framework to the present analysis is recalled:

“In economics, as in everyday parlance, the term ‘evolution’ is often used to simply indicate the process of change over time. In contrast, in the context of Darwinism, the term ‘evolution’ means the process of change that leads to adaptive complexity. If we merely wish to explain change, Darwinism may well offer a useful heuristic, but there is no reason to expect Darwinism to necessarily do a better job than any other theory. However, the value of Darwinism is that it has an explanatory power that is altogether different from merely being able to account for the fact of change over time. It offers a causal logic that is uniquely capable of explaining adaptive complexity. It is from this explanatory power that economic theory stands to gain most. The promise of generalized Darwinism for evolutionary economics is that it offers a rigorous causal logic to explain the evolution of variety from common origins, adaptive fit and the accumulation of design.” (Stoelhorst, 2008, p.347)

The debate on Generalized Darwinism is not finished and the discussion is alive. Stoelhorst’s Synthesis may not be a consensual solution for the problems presented by Generalized Darwinism’s critics. Nonetheless, Stoelhorst formulation is here accepted to be a useful framework for analyzing evolution in financial markets. Thus, the
concluding remark of this chapter is that – as Stoelhorst (2008) argues – Generalized Darwinism and Darwinian mechanisms are applicable to Economics, as long as the object of analysis is evolution, in general, and ‘adaptive fit’, in particular.
V – Evolutionary Forces in Capital Markets

V.1 – The implications of the Debate on the Nature of Evolution in Finance

The criticisms on Generalized Darwinism have implications on the method to be used when studying evolution in Finance. As Finance is part of the social domain, the implications of the Debate on Economic Science are, at least, similar, if not the same.

The arguments pointing to intentionality, survival and cultural retention must be faced in a discussion of evolution in Finance.

The economic agent, facing a given environment, has to respond to it by acting in a certain manner, somehow beneficial to his or her case. The agent acts intentionally, making choices that seem the most suitable under these environmental conditions. This means that agents vary behaviour intentionally, in order to solve the selecting problem that environmental needs posit. Selection and variation are interdependent in a social domain, such as Finance.

Selection in the biological realm implicates death of the entities not adapted. However, in the financial domain, agents do not die because of their decisions. The possibility of returning to the market to make transactions is not excluded; even if some agents leave the market for some reason, agents that might have the same characteristics are always allowed to enter the market. This non-eliminative selection in the financial domain is a critical obstacle, which implies that, if selection is to be considered, then it must be selection of something other than the individual agent, probably a non-physical substance, as an idea.

Retention, in turn, is problematic because of the possibility of culturally driven retentions, which are very different from biological inheritance. Retention in cultural domain is determined by learning processes, in which agents acquire knowledge, depending on their characteristics. This problem, however, will not be fundamentally considered here.
V.2 – Homogeneity

Variety is the starting point of the framework of evolution. The case of homogeneity will be presented before the case of variety, since the former will bring clarity on the importance of the former. Anyway, homogeneity is just a particular case of the possibilities of variety: the case where no variety exists.

Economic theory has a long tradition of considering the homogeneity of agents’ characteristics as a matter of simplification, in order to elaborate conclusions that might hold in a simplified framework of reality. This assumption of homogeneity underlies the strong assumption of economic rationality.³

The process of economic decision and action is derived from the necessity of satisfying a certain goal. The goal of economic behaviour has often been described as the pursuit of self-interest, following Adam Smith (1776). This constitutes one of the main approaches to rational behaviour throughout economic literature. As Edgeworth (1881, p.16) argues, “the first principle of Economics is that every agent is actuated only by self-interest.” This self-interested action has long been represented as maximizing behaviour, where an objective function such as utility is maximized. Utility is no more than “the abstract quality whereby an object serves our purposes” (Jevons, 1888, p.38). Rationality conceptualizes choice as being made exactly according to the maximization of self-interest and this is what makes the assumption of rationality strong. It is neither the assumption of rationality nor the assumption of self-interest, but rather the maximization which is extreme. Behaviour of this kind presupposes that agents are capable of doing all the calculations inherent to maximization, which implicates that cognitive capabilities are unbounded. It is also assumed that this problem has a determinate solution and that it is reached by reasoning. This is a reductionist perspective of agents and, if the conclusions are to hold in the actual world, these hypothetical agents must be equivalent to human beings to some extent, as if human agents were perfectly rational; the results of socio-economic interaction must be equivalent, so that the use of these theoretical agents serves to predict human behaviour in the economic realm.

³The adjective ‘strong’ does not mean that it is strong to assume rationality, but rather that it is strong in the form under which it has been made.
However, this is not the problem that must be treated here in order to study the implications of homogeneity. The first question to be addressed is this: is it possible to assume homogeneity when studying fundamental efficiency of prices in financial markets?

Fama (1965b, p.56) defines an efficient market “as a market where there are large number of rational, profit-maximizers actively competing, with each trying to predict future market values of individual securities, and where important current information is almost freely available to all participants.” Thus, the assumption of rationality and maximization is clearly exposed and there are important implications of this point, especially when we recall that fundamental efficiency is more than reflecting information in prices; it is reflecting information correctly. How information is correctly reflected in prices is something that reasoning tells us.

Since one is interested in why trade takes place when studying efficient capital markets, one may ask how reasoning explains how expectations, which are the basis of trade themselves, are formed. As Sent (2008) explains, the answer is that “since agents are claimed to be optimizers, it is only natural to presume that they will also form their expectations rationally. Hence, some argue that rational expectations hypothesis is nothing but a direct application of the rationality principle to the problem of expectations of future events.”

An important result by Aumann (1976) is that, if agents have common priors and common knowledge about each other’s beliefs, then they cannot rationally agree to disagree. This result has direct implication on the existence of trade, when financial markets are considered and information plays a fundamental role. Does trade take place when we face homogeneous expectations about asset prices? Several authors (Hakansson, Kunkel, and Ohlson, 1982; Milgrom and Stokey, 1982; Rubinstein, 1975; Tirole, 1982; Varian, 2000) argue that it does not, if we hold some assumptions. To understand this argument, “consider a purely speculative market (i.e., a market where the aggregate monetary gain is zero and insurance plays no role). Assume that it is common knowledge that traders are risk averse, rational, have the same prior and that the market clears. Then it is also common knowledge that a trader’s expected monetary gain given this information must be positive in order for him to be willing to trade. The market clearing condition then requires that no trader expect monetary gain from its
trade.” (Tirole, 1982, p.1164). Varian (2000, p. 225) simplifies this assertion to a more intuitive one: “if one agent has information that induces him to want to trade at the current asset price, then other rational agents would be unwilling to trade with him because they realize that he must have superior information”.

The nonexistence of trade under the described perspective leaves no doubt: “unless traders have different priors about the value of a given asset or are able to use the corresponding market for insurance purposes, this market does not give rise to gains from trade. Thus speculation relies on inconsistent plans and is ruled out by rational expectations.” (Tirole, 1982, p.1163). The first case – the existence of different priors – is in fact not a case of homogeneous formation of beliefs; therefore the problem of homogeneous beliefs is not relevant for the present analysis, since homogeneity includes precisely the existence of common priors. The other case – the insurance possibilities –, although of great importance in financial markets, is the same as accepting information-based traders, but not just for purely speculative reasons. Agents must have another goal in mind when trading, under the assumptions of common priors and common knowledge of each other’s beliefs, besides trading for purely speculative reasons. However, pure speculation is fundamental when studying the concept of fundamental efficiency, since adjustments of an asset price towards its fundamental value are made by means of speculative trade and, more than that, motivated by speculative reasons, such as gains. It is the will to make a profit of information – speculation – that drives fundamental efficiency. As Keynes (1973, p.154-155) asserted, agents “are concerned, not with what an investment is really worth to a man who buys it “for keeps”, but with what the market will value it at, under the influence of mass psychology, three month or a year hence.” Although Keynes invokes market psychology and that is not, at least for now, what is at stake, he gives clear and intuitive justification for centring the analysis on the speculation of future prices.

Under the assumption of homogeneity of agents’ beliefs, speculation seems to be undermined, as well as trade for speculative reasons. The presence of speculation in capital markets is ensured if it is assumed that there are heterogeneous priors, that is, if agents are able to agree on disagreeing. This case is no longer a case of homogeneity, but a case of heterogeneity. The possibility of assuming heterogeneity when studying
trade and formation of asset prices is sufficient reason to assume the existence of variety, which is the first premise of a Darwinian model of evolution.

V.3 – Variety

The existence of variety is the fundamental point of an evolutionary process and it is from there that we surely should start.

Variety is fundamental precisely because it determines the behaviour we observe in the interactions of agents of a system. Each agent possesses specific characteristics which precede behaviour. That is to say that the way in which an agent acts reflects its characteristics; differences between agents, and, in particular, between their behaviour, derive ultimately from differences in their characteristics. These sources of variety can be traced to the origins of choice: why do agents choose what they choose?

To answer this question one must analyse human behaviour in the light of a framework of choice behaviour, which has to capture many distinct factors that lead to different patterns of behaviour. McFadden’s framework (1999) proposes that we see choice behaviour as “characterized by a decision process, which is informed by perceptions and beliefs based on available information, and influenced by affect, attitudes, motives, and preferences.” McFadden (1999) explains choice as follows:

“Perceptions are the cognition of sensation. I will use ‘perceptions’ broadly to include beliefs, which are mental models of the world, particularly probability judgments. Affect refers to the emotional state of the decision-maker, and its impact on cognition of the decision task. Attitudes are defined as stable psychological tendencies to evaluate particular entities, outcomes or activities with favor or disfavor. (...) Preferences are comparative judgments between entities. Under certain technical conditions, including completeness and transitivity, preferences can be represented by a numerical scale, or utility. Motives are drives directed toward perceived goals. The cognitive process for decision making is the mental mechanism that defines the cognitive task and the role of perceptions, beliefs, attitudes, preferences, and motives in performing this task to produce a choice.” (McFadden, 1999)
All these factors originate characteristics that determine human behaviour. They do not affect agents in the same predetermined way; that would be the same as to assume homogeneity and agents would behave in the same way when in the same situation. Agents have in fact different characteristics, given that they are influenced by several factors, as for example perceptions or attitudes. It is important to realise that within each factor of analysis there is an enormous spectrum of characteristics that can be assigned to agents. Moreover, it is not sufficient to state that agents are affected by factors such as reason, emotion and attitudes, because that is equivalent to no more than categorizing the characteristics.

First, an agent may be optimistic in his actions, but his degree of optimism can be different from another agent’s; second, optimism is not the only attitude possible, therefore the category of attitudes corresponds to a set of different attitudes; third, characteristics from the set of attitudes can be interdependent with characteristics from the set of emotions, leading to a conjugated effect different from the simple junction of characteristics from both sets. It is therefore necessary to characterize the individual extensively, so that it might be possible to understand how that individual acts when confronted with a particular situation. However, there are too many factors that can affect human behaviour; so many that individual characterizations are impossible, leading to a fundamental, unavoidable problem of unpredictability.

The form of determinism underlying variety of characteristics can be one in which each characteristic ‘x’ implicates behaviour ‘y’ exactly. Even though this might be the case we face in the presence of variety of characteristics and implicated behaviours, given the complexity associated with the enormous spectrum of existent characteristics, and being all those characteristics necessary for the extensive characterization of human action, the predictability of human agency is beyond our capability. Despite existing determined action – hard determinism –, in the presence of variety, we cannot apprehend its causal explanation, because it would implicate to apprehend the whole reality; there is so much variety of characteristics that the causal explanations, although existing, vanish before our eyes in face of complexity. The causal relations may all be reduced to the type ‘x implicates y in exact degree’; but, because there are too many relations of this kind triggered by reality at the same time, even if they are not causally
interrelated, the human perception and comprehension is not capable of capturing the existing causal relations.

However, the determinism implied in variety may not be hard determinism, so that causal explanations may not be reducible to strict laws of the type ‘x implicates y’. In hard determinism, there no such thing as free will. In a looser case of determinism, characteristics affect how the agent chooses, holding as constraints, but they do not preclude the agent from being able or willing to choose the action to be instantiated, which he thinks or feels to be suitable to the situation, from the spectrum of possible actions. In presence of this type of determinism, characteristic ‘x’ may implicate behaviour ‘y’, but not exactly, that is, characteristic ‘x’ may only function as the motive of action ‘y’, but not as determining “already” the action to be instantiated. Characteristic ‘x’ appears then as a motivational constraint, while the last resort of decision is on the side of the willing agent.

With hard determinism, the implication of complexity and its consequent human epistemic limits of apprehending the current state of the world in its whole is that the result is exactly the same as with indeterminism: if hard determinism holds, but the world is too complex, causal relations may be hidden from the common eye, so that one might not be able to know that characteristic ‘x’ strictly implicates the outcome ‘y’; if the type of determinism holds through constraints, maintaining human free will, then characteristic ‘x’ may or not implicate ‘y’, depending on the agent; thus the result of both cases – hard determinism with complexity and looser determinism – is the same: human behaviour apparently not strictly predetermined. It is then irrelevant to assume one or the other, because the result will inevitably be a state wherein we cannot predict behaviour exactly. It might be possible to make predictions as long as characteristics remain as constraints of behaviour, but they will be weak predictions.

Behaviour is then strongly unpredictable, in the presence of variety of characteristics. The question we must raise is whether this has implications on market fundamental efficiency. In order to do so, it is necessary to consider the mechanism of selection.
V.4 – Selection mechanism and Fundamental Efficiency

Selection mechanism is present in the theory of market efficiency: selection ensures the nonexistence of what is said to be irrational behaviour. Brav et al. (2004, p. 398) presents the argument as “the old argument from Alchian and Friedman that, echoing Darwin, irrationality will be selected against, or has been selected against, for long enough to be or to have already been driven to extinction.” De Long et al. (1990, p. 379) describes the implications of such a mechanism insightfully:

“What effect do rational speculators have on asset prices? The standard answer, dating back at least to Friedman (1953), is that rational speculators must stabilize asset prices. Speculators who destabilize asset prices do so by, on average buying when prices are high and selling when prices are low; such destabilizing speculators are quickly eliminated from the market. By contrast, speculators who earn positive profits do so by trading against the less rational investors who move process away from fundamentals. Such speculators rationally counter the deviations of prices from fundamentals and so stabilize them.”

Two major aspects must be ascribed to the hypothesis of market efficiency: (1) there are two distinct types of rationality, ‘rational’ and ‘irrational’ behaviour; (2) the ‘no arbitrage’ principle holds, which implicates that rational behaviour is the one that affects prices, by eliminating deviations from fundamental value.

As for the first aspect, it is clear, from the implications of the Darwinian evolution debate on the nature of evolution in Finance (section V.1), that no one is eliminated from the market – there is no such thing as death in financial markets. Moreover, the supposed ‘irrational’ behaviour is allowed to stay in the market. Whether the behaviour of the so called irrational agents is rational or not is another question, which will be addressed later. For the time being, all that we have to accept is that ‘rational’ means(according to the hypothesis) that the agent formulates its expectation of the future price and return, based on a model that determines theoretical value, given a set of information, and acts according to that valuation. On the other side, ‘irrationality’ means that some agents do not have such behaviour, forcing prices to diverge from the theoretical value.
Our attention must then turn to the ‘no arbitrage’ principle. In a previous section, it was asserted, following Shleifer and Vishny (1997), that arbitrage has practical limits, which relate to the structures and types of strategies in a financial market. The existence of such limits, which are called limits to arbitrage, is sufficient evidence to believe that selection mechanism as it is described by efficient market hypothesis does not hold, because if arbitrage is not observed, the ‘selected’ agents may well be the ‘irrational’ ones.

However, the argument here proposed against such a type of selection – one where there is selection for a specific well behaved agent (the so called ‘rational’) – is another, instead of limits to arbitrage. It is one that recalls the concept of fundamental value. Assuming that every agent that acts in a financial market is ‘rational’ (in the sense of well behaved), whether by eliminating from the analysis the ‘irrational’ behaviour or preventing such ‘irrational’ agents from acting in the market, an asset price is only affected by this rationality principle. Accordingly, price would reveal and incorporate information significant for valuation of the asset, information about expected cash-flows. It is already known from ‘no trade’ theorems that such speculative market could not exist, because there would be no trade taking place and that ‘noise’ is necessary, in order to have efficiency (Black, 1986). Nevertheless, we abstract from that argument and consider that trade would take place hypothetically. One may think that agents would buy or sell assets until prices would reflect their fundamental values. However, a major problem arises: it is assumed that agents can somehow know all the significant information about an asset’s fundamental value, so that he or she might be able to make the valuation. Moreover, it is assumed that the model of valuation that ‘rational’ agents use is the ‘correct’ one and that they all use the same model, then having no model risk. It is the same as assuming that ‘rational’ agents make an objective valuation.

The argument is consequently that such a hypothesis cannot hold, because of the epistemic limits that agents face. If the intrinsic value - the one which holds as fundamentally efficient - is the value of future cash flows actualized to the present, given the set of relevant information, then the implied concept of value is no less than a pure one, an absolute value standing somehow hidden from the subjectivist eye. The intrinsic value establishes the connection between all existent and “imaginary” relevant information and the asset; agents are not able to know this value, since they do not have
the whole set of important information and knowledge and they do not know which model is ‘correct’ model of valuation. They would have to have all information about the current state of the world and to know reality as it is, in order to formulate this theoretical value in absolute terms. This is only at range of an omniscient superior entity. For that value does not depend on extrinsic views, that is, human perspective, it shall be called a value-in-itself⁴. This value is seen as the ‘correct’ expectation, having all information and the ‘correct’ model of valuation. In this case, it is still a value that assumes an ill-defined future⁵, which is not certain, even having all information and knowledge about the world.

Whatever that absolute value might be, it depends on the nature of reality and on wisdom we do not have and, most importantly, that we cannot have (the whole), by virtue of our characteristics as human beings and not omniscient entities in respect to what is valuable when evaluating an asset. This fact – that we do not possess the knowledge necessary to a perfect valuation – makes it impossible to know exactly which the intrinsic value of the asset is.⁶ In short, in the presence of homogeneous human agents acting in the market, the resultant market price is not this intrinsic,

⁴ For the purpose of studying fundamental efficiency, it interests the possible equality or approximation between market price and a theoretical value, which is supposed to exist, since we try to estimate it. Therefore, such an absolute value is supposed to exist. However, the belief in the existence of this value does not implicate its actual existence as a determined or determinable value, altogether independent from human perspective and activity. Indeed, the fundamental value of an asset is said to be an actualization of cash-flows, which did not occur; these are called the fundamentals. These fundamentals depend directly on the interaction of the enterprise with the environment, specially its commercialization of material and immaterial goods to consumers. Thus, the driver of value is the demand of the product of the enterprise. Nonetheless, the value attributed to the product by consumers, via price mechanism, is subjective: it depends on the perspective of the individual consumer of how the product serves his interest, that is, produces utility. This utility, as the abstract quality that the agent attributes to the good, is determined by the perspective, with limited knowledge, of that agent in its interaction with the world; a minor change in his perspective is able to produce an alteration of his subjective judgments. If the price of the good is subjective, then the value of the enterprise, which produces the good, is also subjective. Therefore, a value that exists depending on all relevant information and knowledge, knowable by a superior entity, - a value said to be the ‘correct’ one - is necessarily different from a human value, which depends precisely on the limited knowledge of reality, and that would change if the individual subjective perspective of the agent changed.

⁵ Note that, although the value might be produced with all relevant information and knowledge, it is not necessarily true that the value implied would be determined. This means that the value might still be dependent on probabilities and not determined as in the type of determinism ‘x’ implicates ‘y’.

⁶ It is certain that we may believe that some classes of assets present less risk of estimation than others, as, for example, bonds(when compared to stocks), but the problem with intrinsic value is still present: a bond has characteristics that allows it to have less risk of estimation, since it may have certain cash-flows (fixed income), certain maturity and certain expected growth of cash-flows (normally zero); but it still needs a model of estimation of the risk implied in the obligation of the entity which issued the bond. The necessity of this model conjugated with the impossibility of which is the ‘correct’ one makes the case of bonds still a case of indeterminacy.
absolute value, because human agents are epistemologically bounded, that is, they do not and cannot know the whole reality as it is; on the other hand, market price – assuming there is equilibrium – is as estimation of this intrinsic value, using some model of valuation that those homogeneous agents use. The fundamental point, then, is that, with asymmetric information, market price, even as an aggregate of dispersed information and knowledge between agents, cannot transcend the information and knowledge that agents have as a whole (being the whole the reunion of the parts). If the whole that agents have does not equal the whole of relevant information and knowledge to calculate an absolute, intrinsic value, then market price, as an image of the whole of agents’ beliefs, cannot incorporate the intrinsic value of the asset. Therefore, market price cannot be presented as the intrinsic value of the asset, if as intrinsic value we define value as internal and dependent on all relevant information and knowledge, including that which agents do not have. On the contrary, what agents may formulate is a conditional estimation of that intrinsic value, given a subset of information and knowledge rather than the whole set of relevant information and knowledge.

The problem that arises in the presence of this impossibility of knowing exactly the intrinsic value is that any estimation cannot be compared to the ‘true’ value of an asset, and the process of estimation – the model of valuation – cannot itself be evaluated on the basis of this ‘true’ value; it can only be confronted (when it comes to testability) with experience and observation. Nevertheless, only knowledge of this ‘true’ value would offer definitive and certain feedback about the quality of the estimation, about whether we possess the ‘correct’ model of valuation or not. Simultaneously, this hypothesis of comparing a value from some model of valuation with the ‘true’ value is absurd, given that one is only able to know the ‘true’ value, if one already knows and uses the ‘correct’ model of valuation.

The problem associated with the intrinsic, absolute value is a question of limit, which follows from the epistemological limits that we have. The impossibility of knowing a value that requires the knowledge of the whole of reality means that this value is not what one is interested in when studying financial markets: it is not the intrinsic absolute value at which one is able to aim. However, the implication of this impossibility of knowledge of the whole of reality is knowable: agents that act in a financial market make prices converge – if they converge at all – to a level which is different from that to
which they would make prices converge, if they had more information and knowledge about the current state of the world. Nonetheless, this only proves that arbitrage does not make price converge to an intrinsic, objective value. In order to argue that the ‘no arbitrage’ principle does not hold this argument is still insufficient.

Although agent cannot know the intrinsic value of an asset, they may still have models to estimate theoretical values. In this sense, the fundamental value may be reducible to a conventional value, that is, a value prescribed by a model of valuation, whether or not that value approximates the ideal one. With this conventional value in mind, agents act in financial markets, so that market price converges to that value. In this case, fundamental efficiency is not a concept of intrinsic value, but rather of convention within this socio-economic domain and adjustments towards this value would be possible, if ‘no trade’ theorems did not hold.

However, several problems arise when considering the variety of agents’ characteristics. One of the assumptions implied by homogeneity is that agents, in face of the same piece of information, interpret exactly the same, which is not true when there is variety. In this case, agents might have heterogeneous beliefs and, consequently, differences of opinion. Moreover, agents can use different models of valuation, which implicates model risk (Brav and Heaton, 2003). Two problems had already been presented so far: concerning the inputs of valuation – access to and interpretation of information – and concerning the process of valuation –model risk. When assuming variety, the behaviour considered ‘irrational’ must be accepted: so called ‘irrational’ behaviour can be no more than differences in opinion (concerning the same information), asymmetric information and different views of the world, which are presented as non-normative behaviour. It is non-normative, because the agents do not use the sophisticated models of valuation that prescribe a theoretical value, which are used by the ‘rational’ ones, guiding their behaviour. But how does this affect price convergence, that is, arbitrage?

Arbitrage is well succeeded only if price converges to the value prescribed by some model of equilibrium (formulating efficiency), eliminating inefficiencies in the perspective of that model. If we assume variety of agents, including the “irrational exuberance” they might have, prices are guided by the prevalent, dominant behaviour inside that market and it is here that Keynes’ “mass psychology” plays a major role.
Market forces determine which direction prices are following: if ‘rational’ agents are predominant, prices converge to fundamental values; if not, prices diverge. If it is the case that there are too many ‘irrational’ agents acting in the market, ‘noise’ will be so astonishing that ‘rational’ agents will not risk to make prices converge, since it is more probable that they will not succeed. As Black (1986, p.532) argues, “The information traders will not take large enough positions to eliminate the noise. For one thing, their information gives them an edge, but does not guarantee a profit. Taking a larger position means taking more risk. So there is a limit to how large a position a trader will take.”

It is then the aggregated market power of a group of agents that determines the direction in which prices are going.

The existence of colliding pressures for setting price levels underlines the importance of variety: variety is sufficient reason for accepting unpredictability in changes of financial prices. This is so, because in the presence of variety of agents’ characteristics, a possible hard determinism of those characteristics is clouded by complexity, that is, by the infinitude of characteristics associated with human behaviour. While in presence of homogeneous agents, whose behaviour is all alike, the major source of unpredictability is the possible information about the state of the world that they have, when confronted with variety, heterogeneity presents another source of unpredictability which is human behaviour. Unpredictable behaviour occurs even if it is the case that fundamental information is almost symmetrical between agents. It is, therefore, this case that permits us to understand what changes in the presence of variety: agents with the same information may act differently, because they formulate their expectations about reality differently. Agents could act differently in presence of the same information, but we could be able to understand why they formulate such expectations. It is, however, the indeterminism associated with variety that ensures the unpredictability of action, since we are not capable of knowing exactly how these agents formulate their expectations. These differences in expectations allow for the existence of conflicting views of agents which implicates a struggle for price levels, given that, based on its view, each agent speculates the future direction of price.

If, in a market, price is determined solely by agents, as it is reasonable to admit – since market price is a social construct provoked by the human market forces – , then

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7 ‘Information Traders’ stands for ‘rational traders’.
convergence to a price level can only be an outcome of human activity. *Therefore there is no ‘natural law’ ensuring price convergence, but rather a speculative struggle for price level, where market price is determined by human action.* In this case, arbitrage as convergence to fundamental value of an asset does not hold, and neither does fundamental efficiency. Furthermore, if arbitrage does not hold, selection for behaviour that follows a normative model of valuation (so-called rational behaviour) does not hold either. That is the same as saying that there can be selection for other types of behaviour besides normative behaviour.

The whole argument is reducible to simpler statements:
1 – Market is efficient if the asset’s price reflects its fundamental value.
2 - There are agents that make price converge to its fundamental value (arbitrageurs).
3 – There are no limits to arbitrage.
4 – Then, market is fundamentally efficient.

The argument presented here has been geared to identifying sufficient reasons to reject premise 3. It will be argued the existence of limits to arbitrage is altogether a sufficient and a necessary condition for the existence of evolutionary market forces.

### V.5 – Selection Mechanism and the Necessity of Variety

If a market price is in equilibrium with the theoretical value and that equilibrium is stationary, then, ceteris paribus, there is no mechanism which bears evolutionary pressures onto that state of affairs. If price already reflects all available, relevant information, then, until new (external) information comes into the market, there are no motives or impulses for market prices to change. Thus, the market does not produce endogenously any force which causes prices to move in one direction or another, therefore it cannot produce evolution. Market *is already* efficient and *stays* efficient until new information is brought in. When new information reaches agents transacting in the market, every piece of information is reflected instantaneously in market prices; a new point of stationary equilibrium is reached. Evolution must be endogenously
explained and in a market which already attained the stationary state of an equilibrium value does not force price to enter in disequilibrium, save by external chocks.

In short, if market enters equilibrium there is no endogenous reason for it to regress to a point of disequilibrium. But it is premise 3 on which the adjustments to equilibrium price rest. If there are no limits to arbitrage, prices will converge to fundamental values and equilibrium of price-value is guaranteed (even if price is just an estimation of value and deviations from this value are random). Therefore, if mechanisms which imply evolution are to exist, the market cannot reach a stationary state. Limits to equilibrium must, then, exist. These limits are the limits to arbitrage already pointed out earlier.

In a market that reaches equilibrium through arbitrage forces, the selection mechanism selects for those who speculate in favour of convergence of market price towards theoretical value, based on a model of valuation. Selection as described is only possible because the absence of limits to arbitrage means that convergence occurs with certainty, provided that agents agree on the fundamental value. However, to call a market that selects with certainty the same agents every time that there is selection an evolutionary is absurd, because selection so-described is a priori; that is, we already know whom the market will select before selection even occurs. That is what is implied by the assertion that “irrationality will be selected against” (Brav et al., 2004, p.398) or that “speculators rationally counter the deviations of prices from fundamentals and so stabilize them”, implicating that “speculators who earn positive profits do so by trading against the less rational investors who move process away from fundamentals” (De Long et al., 1990, p. 379). Those assertions eliminate the scope of selection mechanism for events of selection that did not yet occur. A proper mechanism of selection, a mechanism consistent with the Darwinian algorithm of evolution and with the simple existence of adaptive behaviour, environment alterations and complexification of behaviour, must remain open to possibilities rather than to a certain outcome, that is, it must be uncertain. It is uncertainty that allows for the existence of several distinct types of behaviour being selected for, and, specially, it is uncertainty that guarantees selection to be a posteriori: what is selected is selected just after evolutionary forces come into work and obviously it may not always be the same behaviour to be selected. In this sense, when considering financial markets, it is uncertainty what allows for selection of other behaviour that might not be the normative one, what is an unexpected result if we
accept selection as it has been assumed in the classical hypothesis of efficiency, in which so-called ‘irrationality’ is supposed to be selected against and possibly eradicated from the market.

But how can selection be uncertain? It is uncertain for the same reason that limits to arbitrage exist: there is variety of behaviour and this variety is ruled by uncertainty, since we do not know how the characteristics condition agents’ behaviour; price is determined by agents’ behaviour and not by some ‘natural law’ of convergence; price level is determined by those who have the aggregated market power to determine it and that depends on the environment or state of affairs. This uncertainty associated with variety stands as the building block of uncertainty of how market price will react in face of information and which direction it will take. Evolution is explained endogenously by the existence of a variety and the factors interrelated with it: asymmetries of information, interpretation, opinion and knowledge (different views of the world), conjugated with different market power of agents, whose aggregates of market power come into conflict.

A simple illustration is the following: imagine that there are two groups or types of agents and that each one speculates against the other in relation to the future market price of an asset; let us suppose that market price is at a level of 10€ and that one group is betting that price will be at 9€ and the other that the price will be at 11€; if the group who is betting for 11€ has a greater aggregated market power than the other, then price will raise until it reaches at that level of 11€, causing the other group to lose their invested money; thus the group who speculated in favour of a “11€ price” was selected for, and the other was selected against. If it were the “9€ price” group to have the greater market power, then this group would determine price.

Of course, what happens in a market where variety exists is not as simple as this illustration, which is useful only to emphasise that selection occurs as a result of a struggle and that aggregated market power is determinant. Where variety exists, there will be many valuations of an asset; therefore, reasoning in terms of types of agents may be inappropriate. These agents only constitute groups because they bet for a similar price, not because they have the same characteristics.
V.6 – Problems with Selection mechanism

The first major limitation of the concept is its time dimension. The time of selection is a criterion on which selection can be based; here it is argued that time reduces selection to a limitative analysis. In order to understand this problem, the case of survivorship of agents in the market can be taken. DeLong et al. (1990) presents theoretical evidence that supports for the survivorship of the so-called ‘irrational’ behaviour, if the environment is favourable to that kind of behaviour. Survivorship means that agents are able to make long-run profits with their investment strategies. Once again, limits to arbitrage are the main factor allowing for this conclusion: ‘irrationality’ may survive if ‘irrational’ agents influence market prices. Selection is identified with survivorship and the fundamental criterion for classifying selected behaviour is the time dimension of the mechanism, that is, the long-run. The limitation of time can be subdivided into two limitations: (1) investment is not a matter of death in financial markets; and (2) long-run is indeterminate. The first limitation, which has already been presented earlier, is determinant when speaking of survival in the socio-economic domain: not being selected does not mean to ‘die’ in the market; therefore, survival is figurative. The second limitation – the problem of indeterminacy of the long-run– means that the consideration of long-run tries to reduce the scope of selection, placing it in a time horizon, but the concept remains undefined, since long-run is not defined as specific time; how long is ‘long-run’ supposed to mean when studying selection in financial markets? Moreover, one may even question if it is reasonable to attribute to selection a predefined time horizon at all, given that the relevancy of selection mechanism is its interaction with variation and retention mechanism. Time is not included in the formulation of the Darwinian algorithm. The interaction of those mechanisms takes the time necessary to operate not restricted in a predefined time horizon; even if time is relevant, it is determined only a posteriori.

Another major limitation is the inadequacy of associating the substance of the concept of selection with a determined model, since the measure of the selection mechanism varies as we change the model of valuation used. If no agent is eliminated from the market, selected behaviour must be the most successful behaviour in the market from the set of all observed behaviours; in the light of a model measuring performance, selection is evaluated by a risk-return dichotomy. However, there are
several different models that serve explaining or measuring performance and each one sets a risk-adjusted return framework, on the basis of factors justifying returns. If we take, for instance, the CAP-Model and we confront it with the Tri-factorial Model of Fama and French (1993), then a major difference, when measuring performance, arises: the latter has two more factors explaining risk-adjusted returns than the former. Therefore, selection seen as performance in a financial market varies as we vary the model measuring performance, and so does ‘selected’ behaviour.

Since selection is an abstract concept, its usage, when explaining something concrete in a practical domain such as financial markets, tends to be reduced to figurative allusions, approximating selection to a metaphor, more than to a proper mechanism of explanation.
VI – A Darwinian Framework of Evolution in Financial Markets

The Darwinian algorithm is constituted by the mechanisms of variation, retention and selection, and only the combination of these produces the adaptive result associated with an evolutionary framework (Stoelhorst, 2008).

The base from which the algorithm works is the existence of a variety, which in the case of financial markets is the variety of agents’ characteristics: agents act according to their characteristics. In the middle point between characteristics and action, there is a connecting feature which is the individual view of the world: each agent is guided by its own view of how the world works. The variety of human behaviour is permanently interacting with the environment – creating a social environment –, which, in turn, selects the suitable behaviour, under the observed conditions. Driven by intentionality, human understanding (dependent of the individual, subjective view of the world) of what is suitable action under certain conditions produces (intentional) variation of action, which incorporates the new understanding of the environment. Human agents modify their action and interaction, according to their interpretation of the effects produced by the collection of actions of agents. The selection mechanism acts upon this modified behaviour, motivating the appearance of new variations, keeping the process of evolution alive. This continual motion of adaptation and complexification of understanding of the social environment is the missing feature in a stable conception of a social domain, in this case, the financial market. The equilibrium model captures certain tendencies of financial markets but, by definition, cannot explain any evolutionary forces or mechanisms. The equilibrium model does not include any possibility of endogenously explained structural change. The force implied in an equilibrium framework is precisely the convergence to a stable stationary state, responding to external forces, which will produce new situations of equilibrium. An evolutionary model, however, must endogenously explain through its framework an internal motion, which is called evolution.

The interaction of agents, through the combination of individual human agency, individually conditioned by different views of the world sustaining the action of a single agent, sustains a social structure, which is the market. In the case of interactions aiming at the exchange of valuable assets, the market is a structure within the financial domain. The outcome of this market is a market price that, for being determined by the
aggregation of human subjective knowledge represented in human action, results in a social construct coming out from a social structure, which is the market for assets. *The fundamental characteristic of a financial market is then the formation of asset prices.* Changes in the market are mirrored by changes in the formation of prices, and, in turn, this formation reflects the information and knowledge used by agents. Thus the market is an aggregator of the information and knowledge of agents. A model of equilibrium does not include the alteration of understandings about the reality that agents experience, by assuming that this understanding of reality, this *knowledge*, is *stable*. However, evolution in financial markets is precisely driven by these alterations of understandings, of the views of the world: *the source of the continuous evolutionary motion in financial markets is the existence of alterations in the formation of prices.*

Price formation starts by human action; action is determined by the way agents see the world around themselves, specifically their understanding of how the market works, that means, action is the *practical* side of the knowledge of the participants in the market. Nonetheless, prices are social constructs of markets; therefore, they are *solely* determined by human action and interaction, which results in prices being exactly formed by the understanding of how the market works, conjugated with external factors such as (fundamental) information.

On the other hand, changes in prices are feedback information that constitutes positive or negative reinforcement of the views of the world agents have, so producing variation of these views. This conception is similar to Andrew Lo’s conception of an evolutionary financial market. Recalling what has been said previously (Lo, 2004, p. 22):

“Individuals make choices based on past experience and their best guess as to what might be optimal, and they learn by receiving positive or negative reinforcement from the outcomes. If they receive no such reinforcement, they do not learn. In this fashion, individuals develop heuristics to solve various economic challenges, and as long as those challenges remain stable, the heuristics will eventually adapt to yield approximately optimal solutions to them.

If, on the other hand, the environment changes, it should come as no surprise that the heuristics of the old environment are not necessarily well suited to the new.”
Although the idea of reinforcement and learning is the same as Andrew Lo (2004) proposes, the present investigation aims at another feature: markets are social constructs. Social reality, including prices, are the outcome of action and interaction: the way agents see reality conditions how reality is; that is, the way agents see financial markets and price formation conditions the functioning of financial markets and the formation of price itself: this is the principle of reflexivity. Therefore, if agents receive reinforcement under the form of information about how the market works – that is, which are the factors being reflected in prices and in what manner –, the functioning of the market will change, as this new knowledge is reflected in new action. Thus, the reinforcement is the cause of change in the market, through the modification of the method of price formation.

This combination of two propositions – prices determined by action and action itself by knowledge about price formation – implicates the existence of a circular evolutionary force. Price variation and knowledge generate endogenously explained change, which leads to structural modifications of the market through time. This circular connection is concordant with the proposed theory of Soros (2008) that there exists reflexivity in financial markets, that is, prices influence the fundamental value, by influencing the way agents understand reality, then changing it.

Again, reality becomes different if we understand it differently, reflecting those differences in our actions; this is the reflexivity of a human construct. Not only do prices influence fundamentals by influencing expectations, but also price variations influence knowledge of the mechanism of price formation, and knowledge is, in turn, reflected in prices.

Within this continuous motion, the principle of reflexivity is the cause of alterations, through the variation of the views of the world, which are permanently being completed with feedback from each individual agent’s experience. Reflexivity only produces alteration if the feedback received by agents not only exists but is incorporated into their views of the world and their actions. Then, reinforcement, whether positive or negative, is fundamental to produce alterations in the mechanism of price formation. This reinforcement is received in the form of information that needs to be interpreted by the agent possessing it; this interpretation concerns the functioning of the market as an
 aggregator of agent’s expectations and, as the market is a complex structure, this information is obfuscated in a cloud of complexity. This complexity is directly related to the factors that matter for price formation, i.e. the factors being incorporated in prices and the method chosen to incorporate them. This information about the functioning of the market is in turn aggregated with the new external, primary information about assets’ fundamentals and the state of the world generally.

Depending on the interpretation of feedbacks, some information may reinforce some views of the world. Given strong reinforcement, some views of the world become institutionalized and possibly widely accepted. Strong reinforcement is also related to the role of scientific investigation, which presents explanations for some market phenomena. Those explanations develop into theories about the world (or the functioning of the market). Under this possibility of institutionalization of views of the world, the variety of agents’ views can turn into a reduced variety, given the homogenization of the views of the world, produced by the institutionalized theories. It is important to recall that when variety approximates homogeneity, the actions of agents tend to be similar and the effect of this similarity of action is the approximation of an equilibrium market. If the market approaches equilibrium, because agents act similarly, fundamental efficiency is a possibility, that is, market price is able to approach a theoretical value, given by some model of valuation, since the model has become institutionalized. Nonetheless, this value is still a social construction, an institution produced by an institutionalized method, which could be another if institutionalized theories were different.

The homogenization produced by reinforcement is dependent on complexity and on the way that complexity has been interpreted. This means that even when the market participation is homogenized, the process of continuous motion is still operating, although evolutionary forces may be less prominent. The continuous feedback information on the functioning of the market, combined with the complex environment around the market (from which fundamental information comes), is able to produce negative reinforcement on institutionalized theories or views of the world, appearing information about anomalies. The anomaly is a negation of the prescribed efficiency, therefore being a negation of the model valuation; anomalies result in model indeterminacy.
The negative reinforcement appearing in the form of an anomaly is itself feedback and is incorporated in new theories, substituting the former ones. Again, the alteration of institutionalized theories is dependent on the interpretation of the information about the anomaly and on the capability of agents to incorporate a solution to the anomaly in their actions.

In short, the pattern of evolution is an alteration of the views of the world, and that this alteration produces effects on the market, properly on the mechanism of price formation. If the views of the world determine action and, then, prices, the variation of the views of the world necessarily determines the variation of prices. This means that any time in the market if there is a stronger aggregated view of the world, then prices will change, according to that view. The selected behaviour becomes the behaviour capable of determining how the market price varies. Thus, there is selection of views of the world and a practical implication of this selection, which is the selection of price determinacy: if at a first level, selection produces alterations of the views of the world, at a second level, selected behaviour is the one determining the tendency of prices.

The key of the process is the existence of a variety that keeps repeatedly interacting. Price is nothing more than a value changing through time. Now, one can see that what is of great importance is what price is reflecting: following Hayek (1945), price reflects the subjective individual knowledge of each agent, contributing to the formation of that price. This ontological conceptions guide agents’ behaviour; this, in turn, determines market phenomena. Reflexivity is present, since every ontological conception is built on an ontological feedback, that is, feedback from reality, and, simultaneously, the ontological conception guides human agency, affecting the phenomena, defining how the reality giving ontological feedbacks is.
VII – Conclusions

The argument has attempted to present the essence of the concept of value implicitly assumed in paradigmatic statements of the functioning of an efficient financial market, notably the statement that an efficient market price reflects correctly all available information. The theory of value implicit in this statement rests on the concept of fundamental value, which is internally associated with the concept of fundamental efficiency: market is efficient if the produced market price approximates or, ideally, equals the theoretical fundamental value. This formulation of efficiency is set under the framework of an equilibrium model (of valuation) of asset prices. It is here that the concept of Darwinian evolution is allowed to bring some light to the discussion on the merits of this formulation: not only does it help to understand the limits of the paradigmatic model of equilibrium, it also provides a material perspective on the matter of Lo’s adaptive market hypothesis (Lo, 2004). An equilibrium framework of efficiency cannot by any means explain evolution; evolution must be an endogenous variable and, in an equilibrium framework, it is not.

Evolutionary change must be internal and continuous, not external and interrupted. The equilibrium framework does not account for this. This assertion obviously is not questioning the concept of equilibrium and the insightful and comprehensible framework upon which it is sustained. The question has been placed on the consistency of such a model and the exigencies of an evolutionary framework: the endogenously explained evolution cannot be integrated in an equilibrium model, unless the concept of evolution loses its meaning to simply passing to be understood inter-temporal change, somehow incorporated as a mechanistic proposition of the model. Furthermore, the equilibrium stated stands for much more than simple supply and demand equilibrium: here, the equilibrium is normative, for it presupposes that demand equals supply, in the exact point wherein the resulting market price equals a given theoretical value.

Despite Lo’s attempt of transforming the paradigmatic view in the Finance discipline, the adaptive market hypothesis is still connected to the paradigm of efficient markets. Adaptive market hypothesis is a reformulation in the shadows of the seemingly unavoidable concept of efficiency. Nonetheless, the frailty of the concept of fundamental efficiency is exposed, since price incorporates more than fundamental information: price also reflects the method of repercussion of information and the
process through which the method inescapably passes. The adaptation of agents’ behaviour attempts to improve the mainstream theory, by including the possibility of anomalous functioning of the market, leaving, however, the problem of allowing for a multiplicity of usable heuristics, which precludes the existence of an absolute correctness of valuation. The consideration of adaptive behaviour is the first reason for considering evolution to understand the limits of the equilibrium fundamental efficiency: the ideal pattern of an efficient market proposed through the existence of normative valuation of assets, guided by the accepted correct model of valuation, is replaced by a continuously altering, heuristically defined valuation, questioning the existence of an ideal value independent of those perspectival interpretations of the environment; the ideal of objectiveness of value is subject now to reconsideration, leaving space for human subjectiveness.

Fama once said that “We can think of intrinsic values in either of two ways. First, perhaps they just represent market conventions for evaluating the worth of a security by relating it to various factors which affect the earnings of a company. On the other hand, intrinsic values may actually represent equilibrium prices in the economist's sense, i.e., prices that evolve from some dynamic general equilibrium model. For our purposes it is irrelevant which point of view one takes.” (Fama, 1965a, p.36). The conclusion of this investigation is rather different. Once accepting one accepts the argument that an idealized, almost purely designed, value does not exist, since the value of an asset depends inherently on human interpretations and their expectations-based actions, the possibility of modelling asset value, by means of a normative equilibrium framework, is, at least, controversial, if not ostensibly inappropriate. The subjectiveness of human characteristics turns the supposed objective intrinsic value into a value dependent on human action. Most importantly, even if such objective, absolute, intrinsic value existed, the human agent would not be capable of knowing because of epistemic limits. Through the cloud of complexity characterizing reality, agents would construct their models, perpetually attempting to approximate the unreachable intrinsic value; without this intrinsic value to confirm whether they are right or wrong, their estimations could never be corrected; since the knowledge of this value is impossible in exact measure, all the hypotheses concerning the ‘correct’ value remain speculative. Therefore, the possibility of equilibrium is ruled out in favour of the existence of “conventions for evaluating the
worth of a security by relating it to various factors”. If they are conventions, they are just social constructs.

The basis of the framework of Darwinian evolution is the existence of a variety. The existence of variety, jointly with the complexity of reality, sets human action as unpredictable; this unpredictability entails that the market price may not reflect the conventional value of some agents, if the influence of the other agents, with a different behaviour, is greater than the former ones. Therefore, variety helps to understand that price may not reflect a conventional value, and not converge to that value, excluding the hypothesis of arbitrage forces as mechanistic impulses as in an equilibrium framework. Arbitrage may or may not occur; it depends on agents’ market power. Coincidentally or not, the implications of variety are the implications of the premises of the Behavioural Finance Research Program: there are characteristics of agents, which are different (accepting human boundaries); arbitrage may not verify; therefore, market price may not be efficient according to a standard model of valuation, said to be the correct one. Curiously, if, on the one hand, the concept of fundamental efficiency is undermined in grounds of inadequacy when one accepts the foundational premises of Behavioural Finance, on the other hand, a stronger concept of efficiency arises: there cannot be such thing as riskless gains, i.e., not even those who speculate prices to converge to a conventional value (arbitrageurs) are able to profit from arbitrage, at the expense of those who increase the distance between market price and the conventional value, given that arbitrage forces may not be efficacious.

Nevertheless, the use of variety as a premise is insightful but problematic. Variety of agents’ characteristics is nothing more than a ‘black box’, darkened by the infinitude of characteristics. That is, variations of behaviour are so many and so immeasurably uncertain, tending to infinite, that almost nothing can be said about how an agent will act. Obviously, action is expected to be somehow rational; however, if rationality is reduced from its narrowest formulation – that of maximization – to the broader sense implied by variety, a rational agent is simply that agent which uses in his or her favour the logic inherent in the nature of a thinking being. This leads to an obstacle in the application Darwinian framework of evolution to financial markets: variety is the origin of all noise.
The Darwinian algorithm requires three mechanisms: selection, variation, retention (Stoelhorst, 2008). It has been argued that reflexivity emerges in the social domain, following the use of the Darwinian algorithm in financial markets: the ontological conceptions of agents on the nature of reality influence, through their actions, the way reality becomes; how it becomes gives feedback that modifies those ontological conceptions. The implication is that no view of the world is permanently defined or excluded from possible change. Applied to the financial domain, reflexivity and permanent change of views of the world leads to changes in the mechanism of price formation: the factors to be included in valuations of assets change as well as (and most importantly) the way these factors are reflected in prices. A price is nothing more than a unit reflecting this unending process of adaptation of views of the world to the changing environments, not having a permanent, objective form of value.

Curiously, the idea of an absolute intrinsic value not knowable implicates a similar conclusion: in the relentless search to approximate to this theoretical value, the permanent joint hypotheses problem of fundamental efficiency does not permit the definitive confirmation of a single model of valuation, i.e., of a certain, institutionalized view of the world. The permanent joint hypotheses problem is guaranteed by the impossibility of knowing exactly the intrinsic value (independently of its existence), since the absence of this knowledge does not permit to know if it is the market that is inefficient, the model that is incorrect or both of the hypotheses false. Fama explains this concisely: “Tests must be based on a model of equilibrium, and any test is a joint test of efficiency and of the model of equilibrium.” (Fama, 1976, p.143). The permanent joint hypothesis leads to changes in methods of valuation that never ceases. The relationship between the concepts of fundamental efficiency and evolution is, then, that both implicate continual renovation of the views of the world.

The possible homogenization of views of the world in the case the evolutionary method is also similar to the case of equilibrium, in which a conventional value is given and agents accept this value as the guide of their transactions: both lead to possible approximations of an ‘efficient’ market, that is, a market that produces a price approximated to the given view of value, even if this efficiency is illusory.
Recalling Black (1986, p.530),

“Perhaps most importantly, research will be seen as a process leading to reliable and relevant conclusions only very rarely, because of the noise that creeps in at every step. If my conclusions are not accepted, I will blame it on noise.”

Again, variety is the origin of all noise.
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