BEHAVIORAL FINANCE: HISTORY AND FOUNDATIONS

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ABSTRACT

Recent evidence suggests that ideology has the potential to affect academic research in economics and that exposure to a wide range of approaches may increase intellectual diversity, eventually leading to better decisions. Therefore, writing a literature review in behavioral finance, in principle, can bring benefits to a wide range of readers, especially since the field of behavioral finance itself has already grown into a complex web of related but distinct sub-fields and reached a stage when it can guide policy decisions. This review differs from the existent ones as it focuses on the history of the field and its psychological foundations. While the review of psychological foundations is necessary to appreciate the benefits of a behavioral approach and understand its limitations, even a brief historical detour may provide a compelling case against a naïve dichotomy between behavioral and classical finance.

I. INTRODUCTION

Federal Reserve research had been unable to find economies of scale in banking beyond a modest size […] citing such evidence, I noted that "megabanks being formed by growth and consolidation are increasingly complex entities that create the potential for unusually large systemic risks in the national and international economy should they fail" […]. Regrettably, we did little to address the problem.

Alan Greenspan (2010). The Crisis, Brookings Papers on Economic Activity.

I often wondered as the banks increase in size throughout the globe prior to the crash and since: Had bankers discovered economies of scale that FED research had missed?

Alan Greenspan (2014). The Map and the Territory 2.0: Risk, Human Nature, and the Future of Forecasting.

Reading Alan Greenspan's latest book in 2014, I stumbled upon the posed question. Indeed, had bankers discovered economies of scale that FED research had missed? I wondered if Greenspan ever considered a behavioral explanation (hubris hypothesis, Roll, 1986) for the wave of mergers and consolidations in the banking sector or an institutional explanation (Brewer and Jagtiani, 2013) that states that banks receive special treatment after growing over a too-big-to-fail threshold? And if not, was it because these explanations were rejected after thorough investigation or because real human beings overweight their prior beliefs and reluctantly accept ideas that contradict them, as most behavioral economists believe to be a quite accurate description of what we all do?

The questions are, obviously, rhetorical. Yet, as the law of the instrument (Kaplan, 1964) states that we tend to over-rely on familiar tools and ideas, the same way scholars in economics and finance may fail to approach important issues from multiple angles. The degree to which finance and economics in general suffer from a lack of diversity of ideas is a matter of discussion. However, the evidence indicates that ideology influences the results of academic research in economics and leads to sorting into fields, departments, and methodologies (Jelveh et al., 2015).

If an ideology and personal background affect academic views, then exposure to a wide range of approaches should increase intellectual diversity, which in turn should lead to better decisions. Therefore, writing a literature review in behavioral finance still makes sense even though the field lost its controversial status a long time ago (Thaler, 1999a) and nowadays is included in standard textbooks like Hens and Rieger (2016). Namely, I can see at least two reasons.

First, behavioral finance has already grown into a complex web of related but distinct sub-fields of research and providing an overview of recent studies may bring some benefits to the otherwise deeply specialized researchers. Secondly, finance plays an enormous role in most domains of life at virtually any level of aggregation from individuals to governments. Thus, the range of potential readers of the literature review extends beyond one profession. For instance, it is my strong conviction that behavioral finance had reached a stage when it should guide related policy decisions.

Interestingly enough, there is no simple answer to what behavioral finance actually is.[2] There are many ways to define the field and its boundaries, and they mostly depend on the personal perspective of a researcher. For example, to Eugen Fama, a pioneer and a vocal champion of the efficient market hypothesis, behavioral finance is a body of literature mostly preoccupied with attacks on market efficiency (Fama, 2014). On the other side of the spectrum, consider Richard Thaler, a founding father of behavioral finance who made a substantial effort to establish the field as a legitimate part of classical finance (Thaler, 2015 tells a thrilling history of behavioral economics and finance from the perspective of the author). He defines behavioral finance as simply open-minded finance (Thaler, 1993).

Behavioral finance may also be defined by the modifications it has made to a standard finance framework. Here is a catch-all description given by Statman (2014):

> Behavioral finance substitutes normal people for the rational people in standard finance. It substitutes behavioral portfolio theory for mean-variance portfolio theory, and behavioral asset pricing models for the CAPM and other models where expected returns are determined only by risk. [...] Behavioral finance expands the domain of finance beyond portfolios, asset pricing, and market efficiency. It explores the behavior of investors and managers in direct and indirect ways, whether by examining brains in fMRIs or examining wants, errors, preferences, and behavior in questionnaires, experiments, and the field. [...] behavioral finance explores saving and spending behavior [...]. And it explores financial choices affected by culture, fairness, social responsibility, and other expressive and emotional wants.

Finally, behavioral finance is an umbrella-term for a set of research questions which were put together mainly by historical accident. Noah Smith, a Bloomberg View columnist and a former assistant professor of finance at Stony Brook University, identified[3] six different streams of research in finance encompassed by behavioral finance. They range from finance based on informational frictions (starting with seminal works such as Grossman and Stiglitz, 1980; Milgrom and Stokey, 1982) to empirical research on the behavior of individual investors (mostly initiated by Brad Barber and Terry Odean).

The difference in definitions may reaffirm the idea that a researcher's background matters. However, any attempt to define behavioral finance will eventually succumb to the nature of economic agents.

Standard finance assumes that its models are populated by agents empowered with such superpowers as limitless cognitive skills and willpower, and on the other hand restrained to pursue only their self-interest. These three unbounded traits (rationality[4], self-control, and self-interest) form the basis for a so-called Homo Economicus, which is a model used to approximate the behavior of real human beings in a way that can be operationalized for the sake of building economic models. The word "approximate" is crucial. Finance (and economics in general) does not claim that Homo Economicus is a one-to-one representation of real world Homo Sapiens, rather such a portrayal is close enough to reality so we can bear the benefits of the simplification.

Naturally, humans may make mistakes, but people will learn over time and, given sufficient incentives, they will think and try harder to make truly rational choices. And if all of this is not enough, the individual mistakes will still be canceled out in the process of aggregation. These are severe assumptions, but this has not stopped the profession from building itself around Homo Economicus.

Instead, behavioral finance highlights that humans behave quite differently from Homo Economicus by embracing findings from psychology and sociology. This difference, no matter how much it may appear trivial, nonetheless has important consequences since real human beings are inclined to make systematic and predictable mistakes referred to as behavioral biases.

Following Thaler and Sunstein (2008), I will label decision makers described in the models of classic finance as Econs while referring to decision makers as viewed by behavioral finance as Humans.

To illustrate the difference between Humans and Econs, consider the classic example known as the "Asian disease problem" (Tversky and Kahneman, 1985).

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[2] I will not provide a definition of behavioral finance of my own, while sticking to as much a wide definition as possible throughout this article. It also worth mentioning that in principle such terms as finance, financial economics, classical finance, and standard finance may have a slightly different meaning in different contexts. Nevertheless, I will use them interchangeably, unless otherwise specified.

[3] http://noahpinionblog.blogspot.com/2014/02/behavioral-economics-vs-behavioral.html

[4] In this article, the term "rationality" means that an individual knows and follows his or her own preferences as well as the absence of systemic and predictable mistakes in the processing of information.

Imagine that the U.S. is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people. Two alternative programs to combat the disease have been proposed. Assume that the exact scientific estimate of the consequences of the programs is as follows. If Program A is adopted, 200 people will be saved. If Program B is adopted, there is a 1/3 probability that 600 people will be saved, and a 2/3 probability that no people will be saved. Which of the two programs would you favor?

A typical answer to such problem is Program A since the prospect saving 200 people with certainty appears to be more attractive than a risky prospect of equal expected value in Program B. However, the likely answer changes if options are stated differently but the expected values of programs remain the same (only the wording has changed): if Program A is adopted 400 people will die, while if Program B is adopted there is a 1/3 probability that nobody will die, and a 2/3 probability that 600 people will die.

This time, the majority choice is reversed and most people chose Program B. Notice, however, that the only difference between the two conditions is that in the first case the outcome of Program A is described by the number of lives saved and in the second case by the number of lives lost.

Because Econs are focused on the expected value of the programs and have stable preferences, they have no reason to change their minds from one condition to another. On the other hand, Humans are prone to a so-called framing effect, a tendency to react to a particular choice in different ways depending on how the choice is presented. In the example described above, the framing effect leads to a reversal in preferences. In the first case, Humans act as if they are risk-averse and prefer certainty while in the second case, facing a certain loss of 400 lives they became risk-seeking and chose Program B.

It is worth mentioning that besides unbounded rationality, self-control, and self-interest, agents in finance and economics have two very specific additional characteristics. First, their thinking process is approximated by the method of constraint optimization, i.e., economic agents are concerned only with optimizing an objective function (e.g., utility function) with respect to some variables (different consumption goods) in the presence of constraints on those variables (budget constraint). Secondly, modern economics is largely based on the principle of methodological individualism, the idea that we can explain society-wide phenomena by the actions of individuals. In other words, we agree that society is nothing more than the sum of all economic agents (which all are Homo Economicus).

Since neither behavioral economics nor behavioral finance addresses these last two assumptions of human behavior, some scholars state that behavioral modifications of Homo Economicus do not solve the main problem of modern economics (unrealistic assumptions about human behavior and interaction). For instance, Berg and Gigerenzer (2010) call behavioral economics as simply "Neoclassical economics in disguise", meaning that a behavioral approach makes economic agents more realistic, but not realistic enough to take the conclusions of a behavioral economics model seriously. Furthermore, Gerd Gigerenzer proposes a total rethinking of our understanding of human decision-making that goes much further away from traditional economics than behavioral economics and finance (for review see Forbes et al., 2015).

The introduction of this "third" perspective should help readers to escape the false dichotomy between classical and behavioral finance, or neoclassical and behavioral economics in general. Since the behavioral approach is largely based on the same principles of maximization and methodological individualism, behavioral finance does not represent an alternative to a standard finance; rather it should be considered as a set of modifications allowing for more realism while keeping most of the simplicity and usability of Homo Economicus. The same way readers should be warned against the even more simplistic and incorrect dichotomy between "rational" and "irrational" behavior. On one hand, standard finance rests on a quite narrow definition of rationality that allows for many post-hoc non-optimal decisions such as participating in the stock market bubble and suffering severe losses in the process. On the other hand, behavioral finance does not state that people are "irrational", "crazy", or that human behavior is random and cannot be modeled with any sufficient precision. On the contrary, a behavioral approach highlights predictability and a systemic nature of human mistakes so they can be incorporated into a standard framework of classical finance and neoclassical economics.

There is plenty of excellent literature to review on the topic, including such classics as Barberis and Thaler (2003) and Shiller (2003), and more recent ones such as Hirshleifer (2015) and Frydman and Camerer (2016). This review, however, is different as it gives more space to the history of behavioral finance and reviews its psychological foundations.

The need to review the historical background and foundations of behavioral finance deserves additional clarification. Specifically, it is my strong conviction that history provides a compelling case against the naive dichotomy between behavioral and classical finance. Even a brief historical detour will show that the discussion about psychological assumptions of human behavior is only a small part of much larger philosophical and methodological debates in the social sciences and that the proponents of a radical version of Homo Economicus had never won the debate, but rather choose to ignore it.

As a review of the history of behavioral finance should guard the open-minded readers from popular myths and historical fictions (such as behavioral movement is a recent phenomenon), a review of the psychological foundations is necessary to appreciate the benefits of a behavioral approach as well as to understand its limitations. The latter is of immense importance

since proponents of behavioral finance bear the risk of succumbing to the law of the instrument and take the behavioral approach too far, the same way as neoclassical economists did it in the second half of the XX century. As economic imperialism and neoliberalism as its ideological base eventually lead to undesired outcomes,[5] the uncritical acceptance of the normative conclusion of behavioral finance and economics may, in the end, result in inefficient policies as well as create some undesired consequences.

This article is organized as follows. The first section presents a brief historical review of behavioral finance starting from the advent of decision theory by Blaise Pascal in XVII century and concluding with the modern landscape of the field as of 2016. The second section reviews the foundation of behavioral finance by dividing it into micro and macro sub-fields, similar to Merton Miller's distinction between micro-normative and macro-normative streams of research in finance (Miller, 2000). The review of micro behavioral finance aims to contrast the behavior of Humans and Econs in both broad and finance contexts, while the review of macro behavioral finance serves to illustrate that these differences have implications at the aggregate level.

II. HISTORY OF BEHAVIORAL FINANCE

The history of behavioral finance as a particular case of the extensive history of behavioral economics is usually told from the perspective of finance and covers only a recent period. This simplified account starts with the discoveries of market anomalies (empirical findings in contradiction with theories of standard finance) in the 1980s and continues with attempts to explain these anomalies with the foundational ideas of behavioral economics proposed by Daniel Kahneman and Amos Tversky.

Following this narrative to the present, one may notice a paradox of the simultaneous coexistence of both psychological (behavioral finance) and antipsychological (classical finance) ideas within finance. Indeed, proponents of traditional and behavioral finance still have their deep ideological divisions despite at least a 30-year-long debate, which, given that modern finance was born in the early 1950s, preoccupied almost half of the current lifespan of the field.

With the goal to understand this paradox, this article will focus on the long history of interaction between economics (as a progenitor of finance) and psychology before the second half of the XX century, where the story of modern behavioral finance starts with the story of modern behavioral economics.

Following Lewin (1996), I believe that by studying earlier episodes "... we learn that the debate over psychological assumptions is only a small piece of a much larger intellectual debate that concerns the relationship between economics and the other human sciences, most particularly, with sociology". It is my hope that an understanding of the historical background, as well as the repudiation of some historical misconceptions, will help to resolve the paradox and provide a more unified picture of behavioral finance.

As a proper history detour may require space for an entire article, this paper will focus only on a few significant episodes. Namely, I intended to show that (1) the debates over the psychological assumptions already started in the XVII and XVIII centuries and that the advent of expected utility theory (EUT) was a response to a behavioral critique of a rational approach toward decision-making; (2) the classical economists such as Adam Smith as well as early neoclassical economists were hardly a proponents of Homo Economicus; (3) the rise of the psychology-free economics in the late XIX to early XX century was in part influenced by the developments in hard sciences and in psychology itself; and (4) that the period of supposedly psychology-free economics of the first half of the XX century was in truth full of debates over psychological assumptions of the behavior of economic agents.

2.1. Pascal's Wager and the advent of expected utility theory

As a predecessor to behavioral finance, behavioral economics has its origins in early decision theory of the XVII century (Heukelom, 2007). Following Blaise Pascal's ingenious idea (Pascal's Wager) that one should evaluate a decision by the expected value of its outcomes and his discussion of rational solutions to gambling problems with Pierre de Fermat (Samuelson, 1977), decision theory was mostly concerned with the formalization of human behavior and its explanation in mathematical terms.

While Pascal's Wager provided a start for a formal decision theory of rational choice under uncertainty, the Enlightenment mathematicians of probability made no distinction between the rational solution to a problem and how a person would behave (Heukelom, 2007). In other words, no distinction was made between normative (optimal decisions) and descriptive (actual decisions) models of decision-making. Following a long-standing intellectual tradition (in part reinforced by Descartes' false dichotomy of "animal" instincts versus "human" rationality), scholars of the time had an aspiration to unveil and formalize the idealistic decision-making of the rational mind (opposed to the flawed emotional soul).

Despite the apparent success of Pascal's revolution, the attempts to model human behavior in a rational and purely logical way ran into troubles at an early age. It soon became apparent that gambles could be constructed to show that the rational solution is clearly at odds with the real-life observations.

The most famous and consequential of such contradictions, the St. Petersburg paradox, was formulated by Nicolaus Bernoulli in 1713. It follows from the observation that no rational person will agree to pay all his wealth for the opportunity to make a wager with the small probability of an infinite payoff (thus, the bet has an infinite expected value). Over the next three centuries, the paradox grew into an intellectual phenomenon and linked together such prominent figures as the Bernoulli brothers, Nicolaus and Daniel; the inventor of Cramer's rule for solving systems of equations, Gabriel Cramer; the famous explorer of Roman history, Edward Gibbon; Charles Darwin, Thomas Mann, John Maynard Keynes; Karl Menger, one of the leading mathematicians of the XX century; and Paul Samuelson (Samuelson, 1977).

Solutions to the St. Petersburg paradox can generally be divided into four groups: explanations of statistical nature, concerns over finite resources and counterparty risk, diminishing marginal utility, and what we today would call explanations of behavioral economics (Hayden and Platt, 2009).

The most famous and influential explanation of the paradox was given in 1738 by Daniel Bernoulli (Bernoulli, 1954). He proposed that people make decisions not on the basis of expected value, but decisions are instead made based on their expected utility. In other words, what matters is not the amount of money per se, but the pleasure (utility) that they provide to an individual. This way, using the solution to the St. Petersburg paradox, Bernoulli successfully introduced EUT as the basis for the study of rational decisions. The key element to the solution of the paradox was the formulation of diminishing marginal utility of wealth (an equal amount of additional money is more useful for a poor person than an already-wealthy person).

The leading alternative solution to the paradox was proposed in 1713 by Nicolaus Bernoulli himself, as he suggested that events with incredibly small probabilities should be regarded as impossible (Dehling, 1997). Hereby, the younger Bernoulli indirectly and somewhat unknowingly introduced the idea that people may not act in a purely rational matter as they will underweight small probabilities. This idea is in many ways similar to a probability weighting, which is one of the building blocks of the prospect theory – the modern behavioral alternative to the EUT developed by Daniel Kahneman and Amos Tversky in the 1970s.

2.2. Classical and early neoclassical economists

It is not uncommon to assume that the father of modern economics, Adam Smith, was also an inventor of Homo Economicus and the concept of the "invisible hand", an integral part of Homo Economicus and the basis for unlimited self-interest.

A closer look, however, provides us with a rather different picture. In their already quite famous paper, Nava Ashraf, Colin Camerer, and George Loewenstein picture Adam Smith as the first true behavioral economist on the basis of his earlier work "The Theory of Moral Sentiments" (Ashraf et al., 2005):

> Adam Smith's actors […] are driven by an internal struggle between their impulsive, fickle and indispensable passions, and the impartial spectator. They weigh out-of-pocket costs more than opportunity costs, have self-control problems and are overconfident. They display erratic patterns of sympathy but are consistently concerned about fairness and justice. […] In short, Adam Smith's world is not inhabited by dispassionate rational purely self-interested agents, but rather by multidimensional and realistic human beings.

In a similar style, Tomas Sedlacek explores the history of the "invisible hand" in his book Economics of Good and Evil and concludes that it has its roots in the Epic of Gilgamesh, Hebrew and Christian thought, and was explored by Aristophanes and Thomas Aquinas. More importantly, Sedlacek shows that the concept in its modern form originates in the writings of an Anglo-Dutch philosopher, economist and satirist Bernard Mandeville (1670–1733), namely in his Fable of the Bees (1705). In this poem, Mandeville proposes that private vices contribute to public good and are therefore beneficial for society. This is in sharp contrast with Adam Smith's thinking of the benefits of virtue expressed in his The Theory of Moral Sentiments.

The same applies to the other supposed fathers of Homo Economicus such as Menger, Walras, Jevons, and Edgeworth. While it is true that Jevons, Walras, Edgeworth, and the other marginal utilitarians, in their quest to make the utilitarian approach more mathematical and be able to express utility as an explicit quantity, were inspired by the developments in hard sciences of the XIX century (Mirowski, 1992), they also considered utility to be of real psychological substance (Lewin, 1996). In other words, despite these scholars' perception of utility as a gravitational forcefield that directed the actions of humans (Lewin, 1996), they also were looking for the true psychological underpinnings of behavior and motivation.

Likewise, Angner and Loewenstein (2007) point out that the adaptation of the hedonistic principle (individuals seek to maximize pleasure and minimize pain) by early neoclassical economics allowed for both rational and irrational behavior. For instance, the assumption that people maximize pleasure was not in contradiction with mistaken anticipation of pleasure resulting from certain actions.

This pattern is universal and repeats itself constantly. Whenever we start to consider the work of economic historians, it appears that the search for the father of Homo Economicus in its modern sense leaves us with unexpected discoveries. It appears that the thinking of classical and early neoclassical economists was full of references to psychology and allowed for

deviation from purely rational behavior. For instance, Alter (1982) revisits the views of the famous Austrian economist Carl Menger and concludes that the acknowledgment of uncertainty and the existence of the time dimension made him believe in the importance of psychological factors in the explanation of human behavior.

2.3. Quest for psychology-free economics

Despite the fact that major economists of the second half of the XIX century can hardly be regarded as proponents of modern Homo Economicus, the changes in their environment were slowly pushing for the creation of psychology-free economics. The main drivers in this process were the success of XIX century natural sciences with their mechanistic view of the world and the changes in psychology itself starting from the rise of psychophysicists in the 1850s and followed by the rise of behaviorism in the early XX century.

First of all, the late XIX century advancements in physics and chemistry were instrumental in promoting the mechanistic view of society and even made such a view fashionable. As Roy Weintraub writes:[6]

> The very term "social system" is a measure of the success of neoclassical economics, for the idea of a system, with its interacting components, its variables and parameters and constraints, is the language of mid-nineteenth-century physics. This field of rational mechanics was the model for the neoclassical framework. Agents were like atoms; utility was like energy; utility maximization was like the minimization of potential energy, and so forth.

In other words, despite most economists of the period seeming to accept the complex psychological nature of human beings, the success of natural sciences created pressure to uncover similar purely mechanistic and universal laws of individual decision-making and economic interaction.

One of the earliest real possibilities to make economics into a more physics-like discipline came from the developing field of psychophysicists, quantitative investigation of the relationship between physical stimuli and the perceptions they produce. This so-called stimulus-response paradigm in the works of Gustav Fechner produced an inspiring finding for the economists. It turned out that the relationship between wealth and utility proposed by Daniel Bernoulli looks very similar to the relationship between stimulus and subjective sensation (known as the Weber-Fechner law). This finding, in turn, inspired marginalists like Jevons, and later Edgeworth, to reduce the complex notion of utility to a one-dimensional measurement scale of the individual perception of pleasure and pain (Heukelom, 2007), allowing for a major simplification of the complex human nature and reducing the need for psychological assumptions.

Then, in the late XIX century to the early XX century, psychology witnessed the rise of Freudianism with its focus on unconscious, unobservable motives. Because this development went against the mechanistic view of human nature, economists began to find comfort in the gaining popularity of ideas on behaviorism, as it was primarily concerned with observable behavior (Sent, 2004). In the end, it appears that the rise of behaviorism became the major escape route for economists from psychology and its assumptions of human nature. However, in truth, instead of rejecting psychology entirely (as many seem to believe), neoclassical economics simply chose to base itself on a particular vein of psychology (behaviorism). As a result, this means that the neoclassical economics of the XIX century still relies on the psychological ideas of the early XX century that were mostly rejected in the wake of a cognitive revolution in the 1950s.

Finally, the economics of the late XIX century began to lose its aspiration to be a universal social science (Lewin, 1996) as it was prepared to hand over to others the study of social and institutional change in order to free pure economic science from such entanglements (Winch, 1973).

2.4. Challenges to psychology-free economics

It is hard to put the exact date on the birth of Homo Economicus. However, it is possible to argue that the most important advancements were made during a roughly 20-year period, from the early 1930s till the early 1950s. During that time, such scholars like Robbins, Hicks, Allen, Samuelson, von Neumann, Morgenstern, and others created the modern tools of microeconomics that we are still supposed to rely on when analyzing the behavior of rational economic agents.

Although the theory of rational choice was making noticeable progress in the first half of the XX century, its postulates were put under test immediately by the scientific community.

For instance, an experimental economics program was initiated by the Louis Thurstone experiments on individuals' actual indifference curves (graphical representation of the all possible combinations between two different economic goods which has equal utility to the consumer) in the early 1930s and continued by Stephen Rousseas and Albert Hart in the 1940s and Frederick Mosteller and Phillip Nogee in the 1950s. These early experiments concluded that the indifference curves indeed have some basis in reality and that it is possible to construct subjects' utility functions. However, the results are not so good as might be expected.

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[6] http://www.econlib.org/library/Enc1/NeoclassicalEconomics.html

More serious problems started to appear with experiments conducted under risks and uncertainty. For example, the famous hypothetical experiment proposed by Maurice Allais in 1953 (Allais paradox) showed that the theory of maximization of expected utility, which had been accepted for many decades, did not apply to certain empirically realistic decisions under risk and uncertainty.

Another line of testing the basic assumptions of Homo Economicus came from survey data. The famous Lester-Machlup Debate started with Lester's (1946) paper that used survey data to show that corporate managers do not use marginal analysis in their decision-making. The data clearly indicated that the behavior of real humans simply does not confirm the expectations of economists, as the former did not rely on explicit maximization and marginal analysis to guide their decision-making.

However, instead of taking the real-world data seriously and modifying the model of decision-making accordingly, economists appealed to an ingenious argument: it does not matter what people think they do as long as their actions can be approximated with the sufficient accuracy. First, Machlup (1946) came up with the analogy, stating that corporate managers behave the same way a car driver who acts as if he calculates all variables related to driving (e.g., speed, remaining distance, etc.) in a mathematically rigorous way. Then, Friedman (1953) took this defense to a new level by formulating the so-called "as-if" defense of economics:

> Consider the problem of predicting the shots made by an expert billiard player. It seems not at all unreasonable that excellent predictions would be yielded by the hypothesis that the billiard player made his shots as if he knew the complicated mathematical formulas that would give the optimum directions of travel, could estimate accurately by eye the angles, etc., describing the location of the balls, could make lightning calculations from the formulas, and could then make the balls travel in the direction indicated by the formulas. Our confidence in this hypothesis is not based on the belief that billiard players, even expert ones, can or do go through the process described; it derives rather from the belief that, unless in some way or other they were capable of reaching essentially the same result, they would not in fact be expert billiard players.

In other words, proponents of Homo Economicus postulated that the unrealistic assumptions of human behavior do not matter until the theory allows for making reasonably accurate predictions. Psychological assumptions are irrelevant to the validation of theories, and the theories should be judged on the accuracy of predictions. And since the experimental evidence of the day was inconclusive, largely due to the weak experimental designs, most economists sided with Machlup and Friedman.

2.5. Behavioral economics: the "old" and the "new"

By the early 1950s, it became apparent that economics and other social sciences were moving in the separate ways. Armed with Friedman's idea of "as-if economics", the field embraced its psychology-free status, and the dissidents were welcomed to pursue a different career path.

Interestingly, during the next two decades, precisely, when economics decided to isolate itself from the other social sciences, psychology underwent a so-called cognitive revolution, which sought to undermine the dominance of behaviorism (Mirowski, 1992). While the former assumed that the only things that are real are the things one can see and observe (we cannot observe the mind at work, but we can see how people act, react, and behave), the latter provided new insights into the mechanics of the mind and focused on internal psychological processes (Sent, 2004).

Together with the slow accumulation of experimental evidence at odds with the predictions of the model of rational choice, the cognitive revolution allowed for a renewed interest in the psychological assumptions of human behavior. However, despite the works of prominent figures of this new movement such as Herbert Simon and George Katona, their efforts did not have much impact on mainstream economics (Nagatsu, 2015). One of the main reasons behind the limited recognition of these works (Esther-Mirjam Sent refers to this stream of research as "old" behavioral economics) was the lack of conclusive experimental evidence, as the experiments were confined to so-called "small world" situations, i.e., were highly abstract and hypothetical. Such experiments typically involve urns with poker chips of different colors on the basis of which subjects have to compute some probability distribution (Heukelom, 2007). Fortunately, all this changed with the rise of New Behavioral Economics.

Behavioral economics as we know it today (thus, "new" behavioral economics) originated in the early 1970s and was associated with (at that time) two relatively unknown cognitive psychologists, Amos Tversky and Daniel Kahneman, and their studies of decision-making under uncertainty.

In the 1960s, Amos Tversky was working on the theoretical exploration and development of EUT and the related problem of measurement, while Daniel Kahneman's research focus was on the errors of human perception given some external stimuli (Heukelom, 2007). For example, Kahneman was interested how subjective perception of a visual stimulus depends on cognitive load and distractions and found that if you give people simple math problems they would be less likely to perceive a weak visual stimulus which they have no trouble detecting when they are not engaged in such a task. This combination of Tversky's mathematical work on EUT and Kahneman's psychophysical emphasis on the difference between stimulus and perception was a natural fit for a new research agenda of decision-making in real-world situations (Heukelom, 2007).

Kahneman and Tversky started with EUT predictions of how people should behave and began to document the systematic deviation from EUT in realistic decision-making settings. The former was important because economists were not interested in an alternative to EUT, while the latter solved the problem of the excessively unmaterialistic experimental setting of "old" behavioral economics (these two factors partially explain the non-impact of "old" behavioral economics onto mainstream economics). In other words, Kahneman and Tversky accepted the rules of mainstream economics and, by using its own instruments, began to uncover problems with EUT as a good descriptive theory.

2.6. The birth of Behavioral Finance

The rise of behavioral finance was hardly predicted beforehand (Thaler, 2015) as financial models populated with Econs were the most elegant and they had been applied to a real world with what at that time was considered as an enormous success. Also, because financial markets were seen as the most efficient markets of all, it was expected that individual errors would have negligent effect at the aggregate level. Nonetheless, in hindsight, it seems that financial decision-making is one of the least natural for Humans. Thus, there is room for behavioral mistakes in this domain. Finally, the availability of high quality data in finance eventually made these mistakes easy to uncover.

Similar to behavioral economics, behavioral finance needed two ingredients for its development: examples of deviation from predictions of normative theories and some ready-made explanations of such deviations. The latter was provided by ideas from behavioral economics, but the former required an approach different from the one used in behavioral economics where it is was enough to show the examples of behavior that do not conform to the model of Homo Economicus. One of distinct features of finance is that if people will not act as Econs, they will lose money and disappear from financial markets. Thus, individual mistakes cannot reject the assumptions of traditional finance. As a result, to show the importance of behavioral mistakes it was important to point to the existence of market anomalies, i.e., some unexpected market-wide phenomena contradicting the predictions of the existent theory. For behavioral finance to be born, researchers needed to find such market anomalies and successfully explain them with the help of insights from behavioral economics.

The exact date when it happened is a matter of disagreement and depends on personal perspective. Some point to the year of 1994 while others conclude that the beginnings lie in the late 1950s (Bikas et al., 2012). However, the cross-disciplinary consensus points rather to the year 1985 and the publication of De Bondt's and Thaler's (1985) paper on stock market overreaction.

De Bondt and Thaler expanded on already well-known value anomaly. However, they were the first to use a convincing behavioral explanation of the anomaly. It is also worth noting that 1985 saw the publication of two more seminal papers (Shefrin and Statman defined the now well-established "disposition effect", while Mehra and Prescott uncovered the so-called "equity premium puzzle"). Additionally, 1985 was a year when the behavioral approach attracted serious academic attention for the first time during a conference at the University of Chicago, where such heavyweights as Robert Lucas, Merton Miller, and Eugene Fama debated Daniel Kahneman, Amos Tversky, Richard Thaler, and Robert Shiller (Thaler, 2015).

Alternatively, if we want to highlight the importance of research on market anomalies as the origins of behavioral finance, then history also points to the Shiller (1981) paper showing that the volatility of a stock market is much greater than can be explained by rational factors. While Shiller's paper was not the first to explore market anomalies, it was the first to generate academia-wide discussion. In general, research on market anomalies has much deeper roots and can be traced back at least to the 1960s. For example, famous hedge fund manager Victor Niederhoffer, during his academic career at Berkeley in the the 1960s, published a series papers on anomalies in stock market behavior. In the late 1970s, Basu (1977) was the first to formulate and test the value anomaly, i.e., the positive relationship between such valuation metrics as price to earnings ratio and average stock returns, while Banz (1981) later described the related so-called size anomaly: the negative relationship between stock returns and the market capitalization of a firm.

In search of the starting point, those who view behavioral finance as a part of a research stream focused on problems with information processing (finance based on informational frictions) may refer to the Grossman and Stiglitz (1980) and Milgrom and Stokey (1982) papers on information and market efficiency. These first suggested that the prices of financial assets should be wrong to justify the cost of going out and finding new information. The second paper proposed that huge trade volumes in real-world markets may be a sign of some deviation from rationality because in rational markets everyone has almost the same information and thus the motive for trading is rather the second-guessing of the counterparty motives and not an efficient processing of relevant fundamental information.

Finally, if we want to highlight the psychological underpinnings of behavioral finance, then we may conclude that behavioral finance started with Slovic's (1972) paper summarizing psychological findings related to investment decision-making, such as the existence of cognitive limitations in processing information and biases in judgments of probability.

2.7. Modern Behavioral Finance

Behavioral finance reached several significant milestones in the late 1990s and early 2000s. Thaler (1999a) proclaimed the end of behavioral finance in the sense that the field had already become a part of the mainstream. By that time, behavioral finance provided convincing behavioral explanations for many anomalies and proposed a range of behavioral models which had advantages in explaining real world phenomena. For example, Benartzi and Thaler (1995) used the concept of myopic loss aversion to address causes for a historically high equity risk premium (equity premium puzzle). Later, Shleifer and Vishny (1997) introduced the idea of limits to arbitrage in financial markets and basically predicted the situation that the successful and famous hedge fund LTCM found itself in during the 1998 Asian financial crisis, while Hong and Stein (1999) created models that reconciled short-term underreactions and long-term overreactions of stock markets. At the same time, Brad Barber and Terrence Odean started a new wave of research in behavioral finance by documenting behavioral mistakes of individual investors using the data from brokerage accounts. For example, in the seminal paper, Barber and Odean (2001) provide evidence that individual investors achieved sub-par investment results and explained this finding by proposing that overconfidence leads to excessive trading, noting that there is a clear gender difference in the attitude toward trading activity (men are more prone to excessive trading).

In 1999, Andrei Shleifer was awarded the John Bates Clark Medal of the American Economic Association, and in 2000, Matthew Rabin, another scholar advocating the behavioral approach, won a MacArthur Foundation "genius" award and was awarded the John Bates Clark medal in 2001. Also in 2000, Robert Shiller published his famous book Irrational Exuberance in which he correctly predicted the crash of the dotcom stock market bubble, and Andrei Shleifer published the seminal textbook Inefficient Markets: An Introduction to Behavioral Finance. While Shiller's book was instrumental in spreading ideas of behavioral finance to a wider audience, Shleifer also did what was required to compare the efficient market approach with the insights of behavioral finance. He described the role of noise traders (financial market participants whose behavior was different from Econs), arbitrageurs, and investors, and explained how factors such as risk aversion and agency problems could impose limits on arbitrage. Later, Brunnermeier and Nagel (2004), by looking at data on hedge funds' activity during the dotcom bubble, proved that supposedly "smart money" does not necessarily correct the disparity between fundamental and market prices, but rather will "ride the bubble" and confirm the models of noise traders.

Finally, in 2001 George Akerlof, Michael Spence, and Joseph Stiglitz shared the Nobel Prize "for their analyses of markets with asymmetric information", and a year later the Nobel Prize was shared by Daniel Kahneman "for having integrated insights from psychological research into economic science, especially concerning human judgment and decision-making under uncertainty".

In short, in the early 2000s, behavioral finance, and behavioral economics, in general, gained acceptance and respectability after many years of intensive discussions with supporters of the dogmatic neoclassical approach. As Thaler (2015) noted: "Not surprisingly, there have been numerous squabbles with traditionalists who defended the usual way of doing economics. Those squabbles were not always fun at the time but [...] the necessity of fighting those battles has made the field stronger".

At the same time, despite the apparent success of the behavioral approach to finance in the early 2000s the critics were pointing out that behavioral economics, and behavioral finance in particular, still lacks a grand unifying theory of decision-making that can take the place of EUT. This quest for a grand unified theory was at that time predicted by many to become one of the central forces in behavioral finance research in the years to come.

However, it is apparent that the development of the field moved in a different direction: behavioral finance presents itself 10 to 15 years later as an even more diverse and scattered field than it used to be. Instead of unification, the field experienced increased specialization, while the behavioral approach became more widely used to tackle different questions, from the role of households' time preferences in accumulation of credit card debts (Meier and Sprenger, 2010) to the path dependence in corporate costs of borrowing (Dougal et al., 2015).

Additionally, behavioral finance became much more diverse in terms of accepted methods and sources of data. Now behavioral finance utilizes data from functional magnetic resonance imaging, genetic and neurobiological studies, and randomized field experiments; it applies linguistics analysis to identify deception (Larcker and Zakolyukina, 2012), relies on qualitative methods to understand behavioral biases (Sahi et al., 2013), and considers an evolutionary approach for the modeling of financial markets (Evstigneev et al., 2016).

III. FOUNDATIONS OF BEHAVIORAL FINANCE

Just like economics consists of microeconomics and macroeconomics, both finance and behavioral finance can be similarly divided into two somewhat separate parts.

Miller (2000) suggests that research in finance falls into two streams: micro-normative and macro-normative. The first vein is concerned with individual decision-making and is historically associated with the approach taken by Business Schools aiming to

teach students to make high-quality financial decisions. The second approach is historically associated with the research done in Economic Departments with the main goal to derive the dynamic of asset prices from the behavior of individuals.

In the same style, Pompian (2012) proposes a similar approach to describe a variety of topics in behavioral finance. Micro behavioral finance documents behavioral biases of individual investors and its implications for decision-makers. It also tries to uncover the roots of behavioral biases and mechanisms by which they operate. Similarly to the macro-normative stream of research in finance, macro behavioral finance is interested in how the behavior of individual decision-makers determines and influences asset prices. However, unlike the former, macro behavioral finance does not assume that individuals behave like Econs, rather, it is based on the behavior of real humans described by micro behavioral finance.

Inspired by this distinction, this section starts with an account of the theoretical underpinnings of micro behavioral finance by examining the difference between Humans and Econs. Then, the section turns to the most important findings in the realm of macro behavioral finance, which are mostly related to the so-called financial market "anomalies" and the question of financial market efficiency.

3.1. Micro Behavioral Finance

Homo Economicus is a highly-specified model and this fact makes it easy to make a distinction between Econs (suggesting how economic agents behave) and Humans (empirical evidence on how real humans actually behave). In short, Econs should have the following three qualities.

First, Econs should process information efficiently and effortlessly translate it into actions, i.e., correctly retrieve information from their memory; correctly access the accuracy of the knowledge and skills they have; correctly infer new information from observations of their environment; be indifferent to the way information is presented; ignore non-relevant information; make correct probabilistic judgments; and possess the required self-control to execute the needed actions.

Secondly, Econs should have so-called standard preferences that are known to an individual, are stable in time, and do not change under the influence of irrelevant information. Interestingly, the examples of prosocial and other types of behavior contradicting the notion of unbounded self-interest do not constitute a threat to Homo Economicus, at least on the micro level. The theory of rational choice states that economic agents act rationally given their preferences. It means that if an individual investor trades securities on a stock exchange to satisfy his/her sensation seeking, he/she does not act irrationally since he/she satisfies his/her preferences, whatever they might be (sensation seekers are looking for intense and novel experiences associated with risky behavior; Grinblatt and Keloharju, 2009 found that sensation seeking is associated with higher trading activity). The failure to account for the limits of self-interest (in the strict sense of pursuing only one's own monetary gain) may result in incorrect estimation of response to government or business actions. However, this problem has a rather technical nature and potentially can be dealt with through more or better data (the problem is rather how to measure prosocial preferences).

Finally, the model of Homo Economicus implies that people can and will learn from their mistakes and that the process of learning can be described by the so-called Bayesian updating. The latter means that humans have a prior probability estimate (probabilistic estimate given all available information) of the occurrence of some event and when the new relevant information becomes available, we produce a posterior probability estimate (new estimate) by applying the Bayesian rule of updating probabilities. In other words, people apply probabilistic thinking to most real-world situations, efficiently process information, and change their minds based on rules of probabilities estimation.

Behavioral studies have shown that all these propositions are far from the universal truth.

First, Humans make decisions based on the so-called dual process theory of decision-making and over-rely on quick intuitive shortcuts (heuristics) rather than on deliberate thinking, which in the end leads to a variety of behavioral biases. Secondly, real human preferences are better described by the prospect theory, rather than by EUT. Likewise, Humans are not necessarily aware of their preferences, and the preferences themselves may be unstable over time and depend on the way the choice is framed (depend on the way the situation is presented). Finally, there are a number of behavioral phenomena preventing Humans from learning from their own mistakes, and the process of learning is better described by the model of Reinforcement Learning rather than by Bayesian updating. Moreover, Humans experience emotions and those emotions can influence all three ingredients constituting Homo Economicus: processing of information, preferences, and learning.

Behavioral research was also successful in addressing the most often used objection to its findings, namely, the high-stakes argument (when the stakes are high enough, people will make decisions just like Econs). Reviewing the relevant literature, Camerer and Hogarth (1999) concluded that there is simply not enough evidence that Humans act more like Econs during high stakes situations rather than at low stakes. In addition, a recent study (Van Dolder et al., 2015) documented peoples' behavior during particular game shows where participants were making decisions with very substantial sums of money at stake and found no support for the argument that high stakes force Humans to act in accordance with the model of Homo Economicus.

The rest of the sub-section examines these three sources of differences between Econs and Humans in more detail (biases that arise due to the dual process theory of decision-making, the difference in preferences, and limits to learn from own mistakes) and concludes with a discussion of the heterogeneity of behavioral biases, as well as the main factors behind it.

3.1.1. Dual Process Theory of Decision-Making

The Dual process theory of cognition proposes that we use two parallel systems of decision-making. The first system is automatic, effortless, heavily influenced by associations, intuitive, quickly jumps to conclusions, largely unconscious, and mostly based on heuristics (shortcuts or rules of thumb which "represent an adaptive mechanism that saves us time and effort while making daily decisions", Croskerry et al., 2012). The second system is deliberate, conscious, effortful, logical and slow. Most researchers refer to those two systems as System 1 and System 2 (Morewedge and Kahneman, 2010), however, following Haidt and Kesebir (2010) and Hirshleifer (2015), I will refer to them as intuitive and reasoning systems.

To illustrate the difference between the two systems, consider an example. Answer the question: how many people are living in the New York City? Notice that, no matter if you know the right answer of not, you still have an intuitive answer. It probably came to you at once and was based on simple heuristics: I know that a big city has several millions inhabitants, New York is among the biggest cities in the world, so it may have something close to 10 million people (the right answer is 8.5 million). This was an intuitive system at work. It is also reasonable to assume that your answer at least partially depended on the size of the city you live in, because the size of it, no matter how irrelevant it is, still may have influenced the guess of the intuitive system (this is an example of the "anchoring effect", which is discussed later in this section). Now consider a different question: what is the product of 57 and 28? Notice that your intuitive system was most likely silent this time. This was a question designed to be addressed by the reasoning system, while your intuition was not able to provide an easy guess.

The work of these two systems is not entirely separate, rather they may work in parallel, where the intuitive system generates impressions, guesses, and tentative judgments, which might be accepted, blocked, or corrected by the reasoning system (Morewedge and Kahneman, 2010). One of the most colorful and useful metaphors depicting this interaction was popularized by Haidt (2006): "Like a rider on the back of an elephant, the conscious, reasoning part of the mind has only limited control of what the elephant does".

There are two important details about this interaction between the intuitive and reasoning systems.

Firstly, the reasoning system requires a lot of cognitive resources and, thus, most of our decisions are made on autopilot. Lakoff and Johnson (1999) estimated that people spend about 95% of their time under the control of the intuitive system. It also means that most of the decisions produced by the intuitive system go unchecked by the reasoning system. The intuitive system is always involved in decision-making, i.e., the limbic system is consistently interfering with cognitive processes (Loewenstein et al., 2008; Rustichini, 2009) and medical conditions preventing the experience of emotions results in a worse quality of decision-making (Damasio, 2008).

Secondly, the intuitive system was well suited to the human ancestral environment, however, it provides poor guidance for decision-making in a modern complex world (Hirshleifer, 2015). Consequently, since the problems that our mind evolved to deal with are different from today's, heuristics developed by our ancestors are likely to generate systematic and predictable errors in decision-making (behavioral biases).

Despite the idea that our brain is not very well suited to a modern environment may seem highly speculative, there is growing evidence that behavioral biases indeed have evolutionary roots. For instance, Santos and Rosati (2015) review literature on the origins of decision-making and conclude that comparative studies of humans and nonhuman primates' decision-making support the notion of evolutionary roots of behavioral biases. Other studies reached the same conclusion by analyzing isolated behavioral phenomena. For example, Apicella et al. (2014) provide an evolutionary explanation for an endowment effect, while Moshe and Levy (2014) and Zhang et al. (2014) showed the evolutionary origins of risk aversion (both endowment effect and risk aversion are discussed later in this section).

The important conclusion is that the intuitive system has a predominant influence on our decision-making and its reliance on heuristics may lead to predictable and systematic mistakes in specific circumstances.

Literature usually highlights the four most important heuristics: availability, representativeness, anchoring and adjustment, and affect. The first three were introduced by Daniel Kahneman and Amos Tversky in the early 1970s and eventually helped them to formulate prospect theory (Kahneman and Tversky, 1979), which to this day remains the most successful alternative to the EUT.

The availability heuristic is the tendency to estimate the probability of an event based on how prevalent or familiar it appears in our lives (Pompian, 2012). While this is a sensible mental shortcut on its surface, it can result in mistaken estimates because not all past instances of this event are equally retrievable from memory. Thus, people tend to make judgments based on a limited sample of past occurrences, overweighting more recent or more vivid memories. For example, after witnessing a car

accident, people will likely drive more carefully for some time afterwards despite the fact that traffic does not become riskier. Likewise, when investors overweight the last available and more vivid information, they tend to overreact to news which, in turn, helps to explain the positive autocorrelation of returns and momentum.

The extrapolation from past returns is also partially explained by the representativeness heuristic, which states that people judge the probability that an object A belongs to a class B by considering how much A is similar to B, i.e., by relying on formed stereotypes. This leads to all sorts of probabilistic mistakes from sample size neglect (alternatively the law of small numbers) – the tendency to make inferences from too small samples to a conjunction fallacy – the mistaken belief that the conjoint occurrence of two independent events are more probable than the probability of either one occurring alone (famous "Linda problem").

These heuristics, together with self-attribution and hindsight bias (discussed later in this section), result in overconfidence and its correlates (overoptimism and wishful thinking). As a result, Humans display unrealistically positive views of their abilities and prospects and rely on too narrow a confidence interval when estimating probabilities (Alpert and Raiffa, 1982).

The anchoring and adjustment heuristic represents a tendency to place too much weight on the first piece of information available or offered (anchor) when making an estimate. People start with the anchor (no matter how irrelevant it may be) and make adjustments based on the newly received information. The heuristic may cause two sorts of problems. First, Humans are influenced by non-relevant information. For example, Ariely et al. (2003) presented experimental evidence that the last digits of a tax identification number (irrelevant anchor) may influence the willingness to pay for several consumer items (including wine, books, and computer accessories). Secondly, problems arise because the adjustments are usually insufficient and the final estimate remains too close to the initial starting point. For example, Cen et al. (2013) demonstrated that analysts make insufficient adjustments to their earnings forecasts even if such adjustments are well supported by new information.

Finally, Slovic et al. (2002) reformulated and popularized the affect heuristic which states that emotions provide guidance in the process of decision-making. Emotions and feelings help to weight possible outcomes, which simplifies the process of comparison and motivates decisions and actions. The affect heuristic helps to explain well-documented findings that sentiment (time-varying mood swings) can influence asset prices and macroeconomic outcomes. For instance, recent studies found that sentiment affects investors preferences for risk-taking as well as confidence in their own skills and abilities, thus emotions affect both preferences and beliefs (Kuhnen and Knutson, 2011; Bassi et al., 2013).

3.1.2. Preferences: Humans vs. Econs

If Humans behave like Econs, then preferences are known and independent from the way the situation is presented. However, empirical evidence rejects both of these assumptions.

In a creative paper titled Tom Sawyer and the construction of value, Ariely et al. (2006) provide evidence that in some situations people do not have a pre-existing sense regarding a particular experience. Subjects in this study were shown to be easily manipulated by non-normative cues to change their perception from good to bad even if they have tried a similar experience before.

Humans' preferences also depend on the way the situation is described (framing effect), i.e., people make different choices depending on how the choices are presented to them (for example, the "Asian disease problem", described in the introduction). The way we react to a difference in the representation of the problem is called mental accounting (Thaler, 1999b). For example, people treat gains and losses of the same magnitude differently (Kahneman and Tversky, 1979) and sometimes make a distinction between financial assets depending on how they frame them, as belonging to current wealth, current income, or future income (Shefrin and Thaler, 1988). The last example means that Humans treat one dollar in their left pocket differently from one dollar in their right pocket.

Preferences are also shown to be time-inconsistent. Unlike Econs, who applied a stable discount factor to value future payoff, Humans discount near term payoffs much more rapidly than payoffs they expect to receive in the distant future (Laibson, 1997), meaning that the value of the discount factor depends on the characteristics of the situation. Such a difference in approach to near term versus distant rewards is an example of failing to resist a temptation and related to a problem of limited self-control. Interestingly, as early as in the late 1970s and early 1980s, Thaler and Shefrin (1981) illustrated that people are generally aware of this problem and impose personal rules with the goal of increasing their savings. For example, authors describe a case of Christmas clubs, savings programs which were popular in the first half of the XX century in the United States. The design of the scheme was that customers deposit money during the year into a special account, and receive them back before Christmas. Even though such accounts paid no interest, they were nonetheless popular as a part of aa commitment strategy helping to address the problem of insufficient self-control.

The next big thing which distinguishes Humans and Econs is that Humans are loss averse, i.e., they prefer to avoid a loss to acquiring a gain of equal magnitude. In practice, it means that people will unlikely participate in a gamble with an expected value of zero because the negative emotions from the loss of 100 dollars are much more powerful than the positive emotions

from winning 100 dollars. In general, the magnitude of loss aversion is domain and situation specific, but most estimates put the loss aversion coefficient into the range from 1.4 to 4.8, meaning that loses on average are more than twice as powerful as gains (Abdellaoui et al., 2007).

Although it is rather unclear how we should perceive loss aversion, as a preference, a behavioral bias, or as an emotional reaction driven by fear, empirical studies have shown that loss aversion is a universal and important aspect of human behavior (Camerer, 2005). Loss aversion can help explain many behavioral phenomena, from the famous St. Petersburg paradox (Camerer, 2005) to the status quo bias, a tendency to take no actions and follow the chosen decision path (Samuelson and Zeckhauser, 1988). It also explains the endowment effect, a tendency to value things people own relatively more only because of the fact of ownership (Thaler, 1980). Loss aversion seems to be a very basic trait and may have evolutionary origins as it was found present in the behavior of capuchin monkeys (Chen et al., 2006).

The combination of loss aversion and short evaluation horizons produce myopic loss aversion. The latter helps understand relatively high stock market returns (compared to such safe assets as government bonds) over the last century that cannot be explained by the relative riskiness of securities alone (equity premium puzzle). Instead of focusing their attention on stock market returns over the long run, investors focus on short-time price fluctuations. As a result, such investors observe more frequent "paper" losses (negative price changes) and since they are loss averse, investors demand relatively higher compensation (a higher equity premium).

Loss aversion also constitutes one of the main building blocks in the prospect theory (Kahneman and Tversky, 1979), the theory of choice under risk and uncertainty which to this day remains the sole alternative to the standard framework of the EUT.

Prospect theory states that individuals value outcomes of choices they consider to make in relative terms, comparing them to a reference point. Rather than consider the expected value of some risky option, individuals instead will make a decision based on the potential value of gains and losses resulting from such a risky option. First of all, since Humans are loss-averse, they unlikely take a risk if the pleasure they expect to receive from a gain will be lower than the pain they will experience in the case of loss. Secondly, people will exhibit more risk aversion (less tendency to take on risks) if there is a high chance of gain, while they will act in a more risk seeking manner facing the greater probability of loss. It is usually said that Humans are risk-averse in gains, but risk-seeking in losses. Finally, prospect theory considers mistakes people make when they perceive probabilities, namely, it accounts for a tendency to overweight small probabilities and underweight the large ones.

In a seminal review, Barberis (2013) documents a wide list of applications of the prospect theory for the analysis of real-world problems, especially in finance and insurance since prospect theory models decision-making under risk and uncertainty. For example, prospect theory helps explain a robust and widespread finding – the disposition effect, a tendency of individual investors to realize their profits quickly (sell securities which went up in price after they were bought), but hold losing positions for too long (Shefrin and Statman, 1985; Talpsepp, 2011; Li and Yang, 2013). Prospect theory was also successfully used to enrich standard models of consumer choice (Kőszegi and Rabin, 2009; Pagel, 2012), understand business strategy for price setting (Heidhues and Kőszegi, 2012), and explain the intriguing finding of Camerer et al. (1997) that the daily labor supply of New York City cab drivers negatively correlates with the average hourly wage on that day (Crawford and Meng, 2011).

The next important distinction between Humans and Econs in terms of their preferences concerns their motives for making financial decisions. While Econs make investments with the goal to receive utilitarian benefits (increase in wealth), Humans also focus on expressive and emotional benefits of their financial decisions (Statman, 2014). Expressive benefits communicate to others our values, tastes, and status, while emotional benefits represent how our decisions make us feel. For example, by analyzing data from retail brokerage accounts in China, Hong et al. (2014) showed that status concerns may explain a number of stylized facts that characterize the behavior of retail stock market investors, including excessive trading and preferences for stocks with small market capitalization.

If Humans are concerned only with utilitarian benefits, there are still some important differences from the behavior predicted by the model of Homo Economicus. In theory, investors desire high returns with low risk, while the standard deviation of returns constitutes a good proxy for risk. However, the development of psychological risk-return models following Weber and Milliman (1997) and corresponding empirical evidence suggest that Humans perceive risk in a subjective manner, i.e., the same level of objective risk (captured by the standard deviation of returns) may be perceived differently by different people. At the same time, recent studies challenge an even more fundamental assumption that the returns themselves are the most important parameter that matters to investors. Grosshans and Zeisberger (2016) demonstrate that investor satisfaction with an investment depends heavily on the price trajectory by which the final return is achieved. For instance, investors in this study were mostly satisfied when the price path of an investment was first negative before starting to yield positive results.

Finally, except aversion to risk and losses, Humans also tend to avoid ambiguity (ambiguity aversion) and prefer the familiar (preference for the familiar). These effects help to explain limited stock market participation, under-diversification, home bias (failure to diversify stock market portfolio with foreign stocks), and excessive holdings of stock in their own company (Guidolin and Rinaldi, 2013).

3.1.3. Limits to learning from one's own mistakes

Finally, there are several factors preventing Humans from learning from their mistakes and adjusting behavior in the face of non-optimal decision-making. This notion has some parallels with the idea of efficient markets. If there are no constraints (limits to arbitrage), then markets should be efficient. However, in the presence of constraints, markets may be much less efficient than is suggested by the efficient market hypothesis (EMH).

When it comes to learning, Humans face the following constraints. First, people are generally unaware of the role the intuitive system plays in their decision-making, with which the addition of self-attribution, hindsight, and confirmation biases limits the power of feedback we otherwise should receive from our decisions. Secondly, feeling regret, cognitive dissonance, the sunk cost fallacy, status quo biases, and inertia reduce the chance of accepting one's own mistakes and reduce motivation to change the behavior accordingly.

Now let's consider these constraints in more detail.

From the start, we underestimate how flawed and susceptible to behavioral biases our behavior is (Scopelliti et al., 2015). Humans also possess a general tendency to attribute successes to their skills and effort, while failures are attributed to factors beyond their control (self-attribution). Recently, Hoffmann and Post (2014) tested this proposition empirically by combining survey data with matched trading records of a large Dutch discount broker and found that individual investors indeed attributed their recent higher positive returns to their skills. Such a combination of unawareness and attribution of failures to external factors severely limits Humans' ability to identify mistakes to be learned from.

The related finding of Baron and Hershey (1988) suggests that we evaluate decisions by their outcomes and not by the quality of the decision-making process. The latter means that if a bad investment decision had led to a positive outcome by chance alone, the investor will likely view that decision as worth repeating in the future. This finding is related to the concept of reinforcement learning, a Humans' tendency to extrapolate from own direct experience rather than analyze and reflect on all the available data. In other words, economic agents update their understanding of the value of taking a particular action based on the outcome they had received from taking that action previously (Sutton and Barto, 1998).

Additionally, the combination of availability heuristics, overconfidence, and hindsight bias (a tendency to overestimate predictability of certain outcomes after they occurred, also known as the "I-knew-it-all-along" effect) provide Humans with a biased assessment of their track record in predicting a wide range of phenomena, from major geopolitical surprises (Fischhoff and Beyth, 1975) to volatility estimates (Biais and Weber, 2009).

In a related research, Choi et al. (2004) found that cognitive dissonance and the sunk cost fallacy (the decision to stick to the current course of action because of already incurred costs that cannot be recovered) can induce inertia and prevents investors from updating their retirement portfolios in response to changing circumstances.

3.1.4. Variety of behavioral biases and their causes

The list of cognitive biases and heuristics on Wikipedia contains about 177 items. Such a high number may suggest that researchers lack a single unified theory of decision-making. Consequentially, decision-making mistakes made by Humans are explained by parallel, complementary, and sometimes contradictory ideas. Speaking of debiasing[7] strategies, Larrick (2004) suggested that behavioral biases have multiple determinants, and it is highly unlikely that we can find simple causes and establish one-to-one bias to debiasing strategy correspondences.

For instance, 25 years ago, Arkes (1991) suggested that most behavioral biases have only a few general causes and divided them into three categories: strategy-based, association-based, and psychophysically-based errors. Since then, empirical and theoretical works showed that isolated behavioral bias can result from an interplay of different factors (Nickerson, 1998) and some biases are not unitary, but rather represent a collection of different effects and vice versa. For example, availability and representativeness heuristics, in fact, constitute a single heuristic which Kahneman and Frederick (2002) called attribution substitution (however, the tradition to distinguish between the two stuck in both research and practice). Later, Krueger and Funder (2004) produced a list of the 42 most important cognitive biases from the perspective of psychological research, while Carter et al. (2007) list 76 decision biases in business and management and divided them into nine categories.

Despite most empirical studies focusing on one behavioral phenomenon or at a small sample of the population, there is growing evidence that certain groups of individuals are more prone to exhibit behavioral biases than others. Behavioral biases are also to some extent correlated with each other and with other skills and behaviors, like planning and problem-solving abilities, social engagement, alcohol and drug use, and juvenile delinquency (Parker and Fischhoff, 2005).

For instance, using brokerage account data from China, Chen et al. (2007) found that more than 40% of individual and 58% of institutional investors show evidence of more than one behavioral bias. While analyzing Swedish data, Anderson (2007, 2013)

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[7] Emerging applied approach aiming to help both individuals and policy makers to mitigate the effects of behavioral biases.

documented that a low-income, less wealthy, less educated, and less sophisticated investor is more prone to have a less diversified portfolio, trades relatively more, and achieves worse trading results.

In addition, there is also evidence that gender, age, experience, and other factors help to explain some heterogeneity in the manifestation of behavioral biases. However, it is important to keep in mind that the associations with most factors are quite complex and sometimes non-linear, while the explanatory power of many factors may be low and not rather stable. For instance, Kaustia and Luotonen (2016) analyzed factors driving stock market participation and could explain only 30% of the variation in the participation decision and about a third of this explanatory power were captured by institutional factors, while behavioral, cultural, and other recently identified factors explain less than a fifth of the variation.

Among standard individual level explanatory variables, gender is shown to be a robust predictor of overconfidence, since Barber and Odean (2001) proposed in now one of the most cited papers in behavioral finance that men achieve relatively worse trading results because of overtrading, which in turn is caused by a relatively higher level of overconfidence.

On the other hand, the relationship between behavioral biases and age is less straightforward. Korniotis' and Kumar's (2011) study based on U.S. discount brokerage data revealed that investors' cognitive skills and, consequently, investment outcomes decline with age and this negative effect is not fully compensated for by the greater experience of older investors. Alternatively, Li et al. (2013) collected a list of standard cognitive measures for economically important decision-making traits and reached the opposite conclusion, namely, that intelligence and experience gained by older participants compensate for the lower levels of fluid intelligence, especially in the case of temporal discounting (older people are more patient).

Whatever experience helps investors to overcome the decline of their cognitive skills, experience by itself is shown to reduce the influence of behavioral biases (Kaustia et al., 2008). Interestingly, personal experience also affects financial decision-making. Multiple recent studies documented that living through such traumatic experiences as exposure to a civil war, natural disasters (such as Hurricane Katrina), and the Great Depression of the 1930s affects risk-taking behavior, while living through a period of high inflation results in a tendency to have higher inflationary expectations (Frydman and Camerer, 2016).

On the contrary, positive personal experience may indirectly increase risk-taking, for instance, by encouraging participation in a particular kind of investment activity. Kaustia and Knüpfer (2008) investigated the link between investors' past experience and their tendency to subscribe to initial public offerings. Analyzing the behavior of retail investors in 57 Finnish IPOs occurring from 1995 to 2000, the authors concluded that earning a positive return from the first IPO participation substantially increase the probability that such investors will subscribe to future IPO offerings.

Not surprisingly, education is an important factor influencing financial decisions. Christiansen et al. (2008) concluded that individuals holding a university degree in economics have a higher tendency to participate in the stock market, while Liivamägi et al. (2014) found that higher education (economics, business administration, or in information technology) associates with higher risk-adjusted investment results. Additionally, education is found to reduce the influence of some behavioral biases, from self-attribution and anchoring biases (Nguyen and Schuessler, 2012) to the disposition effect (Vaarmets et al., 2016), as well as influence investors' trading activity (Liivamägi, 2016). Naturally, being a smart person also helps as Grinblatt et al. (2012) showed that high-IQ investors are more likely to hold more diversified portfolios and earn higher Sharpe ratios.

Some other factors that might explain heterogeneity in both rational and biased financial decision-making include genetics (Cesarini et al., 2010; Cronqvist and Siegel, 2014), personality traits (Bucciol and Zarri, 2015; Oehler et al., 2016), culture (Chang and Lin, 2015), and experiencing emotions (Kaplanski et al., 2015). Interestingly, a series of studies examining emotional states of financial market participants at work concluded that poor financial performance is a result of having too much or too little emotion, rather than simply experiencing them (Lo et al., 2005; Coates and Herbert, 2008; Liu et al., 2016).

Finally, since behavioral biases are susceptible to environmental clues and framing of the situation, manipulation of seemingly irrelevant factors may influence financial decisions. For example, Bazley et al. (2016) showed that using a red color (compared to black or blue) to communicate financial losses makes investors relatively more risk-averse and more pessimistic about future returns. This susceptibility to the environment is the foundation of one of three major debiasing strategies (along with training and incentives).

3.2. Macro Behavioral Finance

It has long been known that people make mistakes and may enter financial transactions for all the wrong reasons. However, before some scholars were even ready to give up the elegant and simple world of efficient markets in favor of much more complex and messier reality populated by Humans, the behavioral approach was required to overcome a set of (at that time) convincing counterarguments.

When behavioral finance started to take shape as a distinct research field, Thaler (1986) listed four standard objections economists used to offer against taking research in early behavioral economics seriously. Aside from the already discussed mistaken beliefs that people will learn from their mistakes and will act rationally facing high stakes, the list included another

pair of counterarguments. The first stated that individual errors will cancel each other out in aggregation, while the second proposed that arbitrage and competition will eliminate the effects of irrational agents on the market level.

The need to answer these objections embedded in the idea of efficient markets was crucial to the success of behavioral finance and defined the sub-field of behavioral macro finance as we know it today. Behavioral finance responded to the first argument by discovering and documenting market anomalies, empirical facts that were in a sharp contrast with EMH. The response to the second macro argument was addressed with the development of theories of noise traders and limits to arbitrage, which is essentially an explanation of why market anomalies exist in the first place.

For convenience, I will distinguish between the three related but different components of EHM while documenting the most known financial market anomalies, and then discuss the concepts of limited arbitrage and noise traders. These three components are: "no free lunch", "all available information", and the "price is right".

3.2.1. No free lunch

The "no free lunch" component of EMH states that it is impossible to beat the market on a risk-adjusted basis and this view is largely supported by empirical evidence (Rubinstein, 2001; Jones and Wermers, 2011). Therefore, the rise of active management over recent decades seems to contradict the efficient market hypothesis. Interestingly, even John Cochrane, who is hardly a proponent of behavioral finance, noted that the persistence of active management at very high fees remains a puzzle (Cochrane, 2013).

Yet Greenwood and Scharfstein (2012), reflecting on the rise of modern finance, concluded that the net effect of active asset management is rather positive for American society because at least in the 1980s and 1990s it resulted in increased diversification and household participation in the stock market. However, they also note that the growth of asset management after 1997 was rather not beneficial for a society and potentially caused large distortions in the allocation of talent. Along similar lines, Gennaioli et al. (2014) argue that professional money managers reinforce distortions in the allocation of limited financial resources rather than arbitrage them away. The latter does not mean that financial advisers and money managers are totally counterproductive. In some sense, they still provide societal benefits by helping otherwise distrustful and loss averse individuals to participate in the financial markets.

3.2.2. All available information

The second part of EMH reflects the idea that all available information is already taken into account and reflected in current prices. Consequently, this means that the market processes information efficiently even if some individuals are biased and that no public information is useful in predicting asset prices (according to the semi-strong form EMH).

Therefore, the limited attention of individuals and their reading habits should have no effect on asset prices. However, it seems that the stock market is not fully efficient in processing information as it reacts to the same information multiple times when releases of financial information (such as earnings announcements) occur at the same time (Fedyk and Hodson, 2015). Consider a classic case of the biotechnology firm EntreMed described by Huberman and Regev (2001). The stock price of this company went up over 300% on 4 May 1998, a day after the New York Times published a front-page story in its Sunday edition about EntreMed and recent developments in cancer treatment research. The rationality of the otherwise usual stock market reaction was undermined by the fact this article contained virtually the same information that was already published a few months before in the journal Nature and the Times.

The EMH implies that the stock price and, correspondingly, the value of the company should not be influenced by choice of the ticker symbol under which company stock is traded. However, Head et. al. (2009) found that companies with meaningful tickers such as SLOT and ODDS, in the case of casinos, perform better than similar companies with regular tickers. Utilizing the unique feature of the Chinese stock market, namely, that tickers have a numeric form (for example, Bank of China stock is traded in Shanghai under the ticker "601988") and the prevalence of numerical superstition beliefs in China (digits 6,8,9 are considered lucky because their pronunciations sound are similar to positive words such as "longevity" and "prosper", while 4 is associated with the word "death" and considered unlucky), Hirshleifer et al. (2016) found that superstition affects stock market returns. Newly listed Chinese companies with lucky tickers are traded at a premium of over 20%, which dissipates within three years after the IPO leading to underperformance of these companies. Interestingly, company managers are usually aware of such inefficiencies and eager to exploit them for their own or in the company's interest, which in literature is referred as "catering".

Then, there is a large body of literature documenting the existence of some predictability in asset prices, especially in the aftermath of large price movements. Stock prices move in the same direction in the short run (positive autocorrelation of returns, sometimes referred as momentum), while in the long run stocks tend to do the opposite (negative autocorrelation of returns, sometimes referred as reversal).

The academic interest in this topic started to gain widespread attention after De Bondt and Thaler (1985) showed that a stock market portfolio constructed of past losers (stocks that experienced a decline in price over a recent period) substantially

outperformed a portfolio of past winners over the next three years. In the world of EMH, such a finding would be impossible because the information about stocks' past performance is publicly available, already reflected in market prices and useless for prediction.

DeBondt and Thaler explained their finding by proposing the overreaction hypothesis. Investors tend to overreact to current information and become excessively optimistic (pessimistic) after a series of good (bad) news. In other words, in an uncertain world, investors overweight the last available information and their recent experience. Such overreaction leads to a growing difference in fundamental and market prices, while it disappears with the passing of time and arrival of more recent information.

In the complementary line of inquiry, Jegadeesh and Titman (1993) proposed underreaction hypothesis to explain the tendency of stock prices to slowly incorporate new information, which gives rise to the positive autocorrelation of returns. The hypothesis states that investors are behaving conservatively and overweight their prior beliefs, which leads to underreaction to news and causes what is known as post-earnings announcement drift, the tendency of a stock price to move in the direction of an earnings surprise for some time after an earnings announcement. While underreaction hypothesis is mostly dealing with market reaction to information, momentum is a more general phenomenon and can also be explained by the effects of reinforcement learning and representativeness heuristic. For instance, investors are shown to naïvely extrapolate future returns from the past in all kinds of research setups from experimental markets and surveys to field experiments (Hirshleifer, 2015).

Both overreaction and underreaction can occur at the same time. Investigating the connection between stock market moves and major world events, Niederhoffer (1971) reported that stocks exhibit short-term price continuations and at the same time show a tendency to overact to major negative news as the death or serious illness of a world leader. Later, with the advent of behavioral arguments, several theoretical models were proposed to explain both momentum and reversals. Daniel et al. (1998) suggested that overconfident investors put too much weight on private information (information they already have), which leads to overreaction, but they underweight public information (news) because of self-attribution bias, causing underreaction. Hong and Stein (1999) in turn made a more basic distinction and built their model on the interaction of two groups of traders: news watchers and momentum traders. The former react to private and slowly diffusing public information concerning company fundamentals, while the latter exploit momentum in stock prices created by the action of news watchers. The model also stresses that information diffuses quite slowly among investors and, consequently, both phenomena are likely to occur in the stock of small companies receiving relatively little attention from analysts. Later, Barberis and Shleifer (2003) show how a trader who switches between different trading styles depending on their relative performance can cause stock price over- and underreaction. More recently, Vayanos and Woolley (2013) extended the idea of Barberis and Shleifer and proposed that mutual fund flows can explain momentum and reversals and make both strategies profitable to exploit.

Besides behavioral explanations, scholars propose a number of possible explanations for observed predictability in asset markets ranging from the dominant role of the market microstructure to changes in investors' perception of risk. Reviewing relevant studies, Amini et al. (2013) concluded that despite this field of research being highly fragmented in terms of different methodological approaches and different proposed explanations, predictable patterns in asset prices are robust to non-behavioral explanations and the effect has not disappeared or declined over time. Interestingly, Amini et al. (2013) note that the patterns of predictable behavior in asset prices are unlikely to yield abnormal returns for those intended to exploit such predictability (because of trading costs, price impact of trades, and other factors).

3.2.3. Price is right

The third element of efficient market hypothesis is the most important and at the same time is the most difficult to test empirically. As Baker and Wurgler (2011) put it, violations of EHM are not that important if they lead only to transfers of wealth among investors, from less to more rational. However, the problem becomes one of paramount importance if mispricing leads to the misallocation of limited financial resources and resulting deadweight loss for the economy.

Given the gravity of the question, it may be surprising that researchers still have no conclusive answer if EMH is true and prices reflect fundamentals. This state of affairs was explained by Fama's (1991) emphasis on the observation that market efficiency per se is not testable because of a joint hypothesis problem: to be able to compare market prices with fundamental values we need a theory explaining what these fundamental values are. Indeed, if the test of a price-is-right component of EMH indicates that prices are not right, it is impossible to conclude that markets are inefficient because the result may be driven by the failure of the asset pricing model used to provide true fundamental values of tested assets.

And indeed, despite the capital asset price model (CAPM) being rejected by Fama and French (1992), neither the shift of attention to purely empirical asset price models (such as the Fama-French three-factor model) nor the development of behavioral alternatives (such as Shefrin and Statman, 2000) have led to satisfying results and few are satisfied with the current state of asset pricing models (Statman, 2014). While predictions of CAPM simply have no basis in reality (e.g., Frazzini and Pedersen (2014) recently show that high-beta stocks underperform low-beta stocks which are the opposite of CAPM prediction), empirical asset pricing model becomes a field of factor mining. For example, Harvey et al. (2015) document over 300 factors used in prior research to explain the cross-section of expected returns and argue that most of the claimed findings are likely to be false because of the use of too low t-statistic to identify significance.

Fortunately, researchers found indirect ways to solve the problem of joint hypothesis testing. Over the years, behavioral finance has documented multiple cases of mispricing of securities, while laboratory experiments and the idea of limits to arbitrage shed a light on the driving forces behind such mispricing.

A special case of the more general thesis of "price is right" states that two identical financial assets should have equal prices. However, the now famous analysis of the price behavior of twin shares of Royal Dutch/Shell and Unilever NV/PLC revealed that even if the true fundamental relative value of two securities is unambiguously known and fixed, the ratio of market prices of such securities may deviate from its fundamental level for a prolonged period. Similarly, researchers discovered that the prices of closed-end funds may substantially deviate from funds' net asset values despite the fact that the two prices should be equal (for review, see Lamont and Thaler, 2003). Since such cases of mispricing received their first major attention in the early 1990s, analogous cases were documented all around the world and asset classes, including the market for derivatives in China (Xiong and Yu, 2011) and the U.S. bond market (Fleckenstein et al., 2014).

The next obvious example of violations of EMH is the existence of bubbles, situations when asset prices increase far above their fundamental value and eventually crash back. Despite financial bubbles being an essential part of human history (Kindleberger and Aliber, 2005) along with financial crises (Reinhart and Rogoff, 2008), the academic view of this phenomenon substantially differs from the common perception. Fama (2014) points out that bubble literature suffers from ex-post selection bias, meaning that financial bubbles are easy to identify after the fact, but almost impossible to predict in advance, and most of the successful prediction of financial bubbles are simply a result of cherry picking stories of success. In other words, despite recent advances in econometric methods, the identification of asset price bubbles is still beyond our reach and most findings are not robust (Gürkaynak, 2008).

On the other hand, researchers were able to create robust asset price bubbles in laboratory experiments. Following the seminal work of Smith et al. (1988), the existence of bubbles in experimental financial markets was created a countless number of times and experimental asset markets research already reached the level when it may be carried on with a standardized open source software (Palan, 2015). Despite the fundamental (intrinsic) value of the particular asset being known to experimental subjects, prices tend to peak well above the fundamental value before the bubble starts to burst. Naturally, the size of a bubble negatively depends on the cognitive skills and experience of market participants (Palan, 2013). The other robust finding is that the possibility of short selling of assets does not prevent bubbles in experimental markets (Haruvy and Noussair, 2006). The latter, however, is not equivalent to the statement that financial markets are indifferent to short-selling restrictions. On the contrary, the restriction of short selling practices is shown to have no positive effect on the mitigation of market panic but has a negative effect on market liquidity (Kim et al., 2016).

3.2.4. Noise traders and limits to arbitrage

To explain the existence of financial market anomalies, it is essential to take two steps. First, we must assume that the behavior of some market participants systemically deviates from predictions of a rational model of decision-making. Secondly, the other group of market participants should find themselves in a situation when there are some constraints in the way to exploit mispricing to their own benefit. In other words, for anomalies to exist, rational agents should interact with a group of noise traders in a world with limits to arbitrage.

The concept of noise traders was first proposed in a Fischer Black (1986) address to an American Finance Association meeting. Black defined noise traders as those who make their decision based on noise as if it was information, meaning if a person makes a trade not on the basis of the rational analysis of relevant information that is useful to predict future fundamentals (such as earnings), then such a person is a noise trader. By this definition, Black made a suggestion to early scholars of behavioral finance – critics of EMH had to show that noise traders influence market prices, which Black himself hardly expected since he also stated in the address that "[…] almost all markets are efficient most of the time".

The idea that arbitrage in financial markets may have its limits was well known and such constraints to arbitrage as restrictions on short selling was shown to cause mispricing. For instance, Miller (1977) theoretically demonstrated that restriction of short-selling can develop into a situation when a price reflects only one side of a wide range of views since pessimists cannot express their opinion by shorting the stock. What was lacking in this and other early models was an explanation as to why some investors are willing to buy and hold an overpriced asset, especially if most investors are rational by their nature, and, most importantly, the model provides no answer to Friedman's (1953) critique that irrational investors will lose money to arbitrageurs and eventually disappear from the marketplace.

The first model to address these limitations was developed in the early 1990s by Bradford De Long, Andrei Shleifer, Lawrence Summers, and Robert Waldmann (De Long et al., 1990). The major innovation was to show that the existence of noise traders poses a risk for arbitrageurs since the sentiment of the first group may become even more extreme over time (risk was previously shown to be a constraint that can limit arbitrage opportunities). If arbitrageurs are risk-averse and have short term horizons, then the ability of noise traders to earn positive returns for a long time by bearing more risk will eventually lead to persistence of mispricing. While this model contained a number of important innovations, the main contribution was to show that noise traders and limits to arbitrage taken together create a world much different than predicted by EMH and that noise traders cannot be dismissed with Friedman's argument.

Later, with several important works of other authors, this model became a major building block in literature dedicated to the problem of limits to arbitrage. In a seminal paper, Shleifer and Vishny (1997) expanded on idea of limits of arbitrage, Hirshleifer et al. (2006) show that the actions of noise traders can induce self-validating feedback into fundamentals which allow them to earn higher profits than is available for arbitrageurs, while Hong and Stein (2007) explain how heterogeneity of opinions lead to changes in sentiment which was exogenous in the model of De Long et al. (1990).

In probably the most well-known article in behavioral macro finance, Shleifer and Vishny (1997) stressed the importance of capital constraint (capital is much less available in the real-world than in the case of textbook arbitrage) and highlighted the agency problem. Since arbitrageurs are professional money managers raising capital from endowments, banks, wealthy individuals, and other investors, they are affected by capital inflows and outflows. If investors, who provide capital, suffer from loss aversion and extrapolate future returns from the recent past, then arbitrageurs run a constant risk that investors will start to redeem their money at the worst possible moment, when market prices move against the arbitrageur.

Besides the notion that noise traders interact with rational agents (smart money) in the world of limits of arbitrage, another series of relevant findings suggest that many market participants hardly behave as Econs either. For instance, behavioral finance challenged a belief that security analysts present an additional rational force that helps financial markets achieve efficiency. Since an early finding by De Bondt and Thaler (1990) that analysts show signs of overreaction, i.e., that their forecasts are too extreme to be considered rational, additional evidence had confirmed that analysts indeed behave much more like Humans rather than "smart money". In general, security analysts were shown to be overoptimistic and having a conflict of interest (Richardson et al., 2004; Mola, 2013), as well as attempting to ride market sentiment rather than correct the market toward fundamental prices (Corredor et al., 2013) and also to be influenced by their personality traits (Jiang et al., 2016) and social environment (König, 2016).

That is not to say that all market participants are noise traders and that limits to arbitrage completely prevent correction of mispricing. Akbas et al. (2015) compared money inflows into mutual funds (dumb money) and to hedge funds (smart money) and the consequent dynamics of some proxy measures of market mispricing and concluded that money inflows to hedge funds contribute to the correction of mispricing.

IV. CONCLUSION

This review of the history of behavioral finance and its foundations is intended to serve as an extensive introduction to the field for novice readers, as well as to affirm several broad ideas.

A closer look at the history of the field reveals that the psychology-free economics of the 1950s–1970s appears to be an interlude in the long lasting and complex relationship between psychology and other social sciences on one hand, and economics and finance on the other. It also seems that neither economics nor finance were ever truly psychology-free and, instead of rejecting psychology, economics was rather defined by it. Homo Economicus also appears to be a product of the intellectual environment of late the XIX to early XX centuries with characteristic dominance of mechanistic and deterministic views of the world. However, as Dow (2003) points out, many sources of this inspiration are long gone, as many predominant views in the fields of theoretical physics, psychology, and even mathematics all underwent substantial changes.

Another lesson of history indicates that the development of behavioral economics and behavioral finance was defined by their striving to prove themselves worthy of inclusion into the mainstream. This need to wage a constant war against the predominant and even orthodox approach has left its mark on both behavioral approaches as it developed as a "negative science", with the main goal of rejecting explicit and implicit hypothesis proposed by neoclassical economics and standard finance.

Finally, the overwhelming evidence against Homo Economicus as a realistic description of real humans as well as a compelling case against the efficient market hypothesis does not mean that behavioral finance holds the keys to all important answers. For instance, as the discussion of the variety of behavioral biases and their causes illustrates, we still do not know how exactly such a basic trait as age affects our propensity to make systemic and predictable mistakes.

Likewise, as a part of the mainstream, behavioral economics and finance (at least at this stage) leave out many important issues such as methodological individualism or complexity. By including Humans in its models, behavioral finance certainly improves our understanding of the real world. However neither behavioral economics nor behavioral finance can be used as a substitute for an inclusive interdisciplinary approach to important real-world problems.

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