

THE HOMO NEUROECONOMICUS - A WINDOW FOR THE FUTURE

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ABSTRACT

This paper analyzes the validity (and also the framework) of the rationality postulate on the moments of decision-making by economic agents, as it is promoted by the economic and financial fields on investigation, especially on microeconomic and portfolio theories and models. The main features surrounding this postulate are addressed to the aims of this study and are criticized considering the developments achieved on the neuroscience investigation on human being decision-making process. There are considerable developments got in several areas, mainly for example in the area of the effects of dopamine on the preference ordering (and the subsequent relation with the reversal of preferences hypothesis), in the area of the proprieties of oxytocin on the decision and choice under social situations and context, and in the areas of the somatic marker hypothesis and of the value of emotions. The magnitude of the importance of memory processes (operative and long-term memory) in connection with somatic states in decision-making problems is also highlighted. These features are sensitized on what can constitute the basis for the construction and definition of an alternative profile of the economic agent, which analysis will be tested later in the investigation, dealing with problems of decision-making and choice in game theory environment (especially in dynamic or iterated games).

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[I] INTRODUCTION

The economic and financial areas had based most of their theories and studies surrounding the postulate that the economic agent, a single human being, is driven by a set of propositions that jointly imply a full rational process of thinking and action. However, the latest occurrences in the economic world (financial crashes, public debt crisis and macroeconomic recessions) have weakened the validity of these models and theories. The solution for this problem may be got on one of the most basic propositions usually made: the rationality postulate.

Especially in last years, the lack of explanatory efficiency of the homo economicus, a notion firstly addressed by Stuart Mill on his "Essays on Some Unsettled Questions of Political Economy" (see Mill [1]) and "Principles of Political Economy" (see Mill [2]), following the ideas of Adam Smith and Thomas Malthus, implied the emergence of a growing number of critiques, firstly made by economic behaviorists, sociologists and psychologists and later by economic researchers in partnership with neuroscientists. Particularly, this last field, denominated as Neuroeconomics and Neurofinance, brings an explanation for the actions made by the economic agent through the analysis of his neural circuits and brain, especially in decision-making moments. Evidences from several studies in this field suggest the launch of a new architecture of the process of decision-making of the economic agent.

Based on this context, in the present study, firstly, a review over the main features of the rationality postulate is made, which are used on several economic, financial and game theory models, as the existence of a stable and complete set of preferences, a full information processing, monotonicity and the utility paradigm. Then, critiques and alternatives based on neuroscience investigation findings are presented, concretely related to the possible dichotomy existing on the moment of choice, the influence of the social environment in decision, the somatic marker hypothesis and the emotions importance, and also the main features of the memory processes. Finally a brief discussion on the main results of the study and on what can be the future for the economic and financial areas is launched, opening a window for the construction of a more realistic profile for the economic agent.

[II] THE POSTULATE OF RATIONALITY IN ECONOMIC AND FINANCIAL AREAS

The notion that the economic agents (as the consumer, the business manager or the investor) base their decisions in a perfect rational structure has become so deep in the economic theory that for many theorists, it is almost impossible to see another "valid" hypothesis. The real problem deals with the real conviction that the greater part of the economists have on this postulate, and their skepticism to accept its anomalies. For instance, Frey and Eichenberger [3] have presented on their

study of 1989 the reactions from economists to empirical evidences showing the violation of this postulate. The main conclusion reached was based on their denial in order to accept individual behavior anomalies, what is justified as a product that resulted from artificial laboratorial results, and from aggregate behaviors, because is defended that these anomalies are random and compensated with efficient behaviors, like the ones seen on competitive markets. A possible explanation for the general usage of the rationality postulate may reside, in a methodological plan, in the dependence and addiction from economic theorists in the utilization of a normative analysis, which is concerned with the rational solution for a choice and decision-making problem, instead of a descriptive analysis (see Silva *et al.* [4]). Nevertheless, since the Classical Era, the assumption of rationality has been taken as a central premise on almost every model, and it is so strong that for some economists (like Lionel Robbins or Von Mises), it was almost an a priori proposition.

2.1. A brief historic overview

The understanding and usage of the rationality proposition, for economists of different eras, was not always the same. For classical economists, like Stuart Mill [1, 2, 5] or Adam Smith [6], rationality was related to the preference to achieve the highest profitability at the lowest costs in order to accomplish only the self-interest. Later, it evolved to the utility theory, which is related to the maximization of the expected utility of a consistent set of preferences, in a certainty context (see Broome [7]). In the following years, notably in response to the evolution of the financial markets, and benefiting from the expansion of the game theory field, a “refined” notion of rationality was reached.

The works of Von Neumann and Morgenstern [8, 9] and the contributions of John Nash [10, 11, 12, 13] are important in this area in problems dealing with a situation of conflict between two or more agents (or one player versus nature). The main objective is the achievement of the desires and motivations of players, what is accomplished through the use of different strategies, which were essentially based on the rationality proposition presented on the last paragraph (more pronounced on non cooperative games). However, in these cases, the rational decision-making was obtained in a context of uncertainty, which did not invalidate the efficiency of the choice.

This rationality scheme was also explored on the financial area of research, initially by Markowitz [14] on his Portfolio Theory, and followed notably by Sharpe [15], Lintner [16] and Mossin [17] in the Capital Asset Pricing Model (CAPM) and Ross [18] in the Arbitrage Pricing Theory (APT). In these cases, a rational investor maximizes (or should maximize) the discount expected returns and diversifies (or should diversify) his funds among all available securities, conducting him to a situation of maximum

return and to a mean-variance portfolio in a market with imperfect information.

2.2. The main features of rationality

Taking support in the previous point, the main features of rationality and consequently the processing and use of information in decision-making process can be summarized on the ideas of Simon [19]. It is assumed that a rational agent has the knowledge to make the best possible decisions in the existing environment and with intrinsic limitations, supported by a well-organized and stable system of preferences, on a context of perfect information (or in cases of imperfect information, with the ability to process and to adapt quickly to new information), what leads him to the best possible decision (see Simon [19] and Silva *et al.* [4]).

Thus, there are three main points that jointly form the basis of the proposition of rationality. Firstly, it is assumed that all agents have a complete, organized and stable set of preferences. By this way, facing a process of decision-making, an individual will choose the highest ranked option on the internal set of preferences, i.e., the alternative which best satisfies his needs of the moment and best matches his self-interest.

The system of preferences is strictly related to the monotonic feature, which, in simple terms means “more is better”. The system of preferences is built on the expected marginal utility that comes from a given choice, implying that the decision has to be the one that satisfies, in the larger extent, the needs of that moment. The only allowed moment of ambiguity occurs when the individual faces two choices that are indifferent because he has the same expected marginal utility (see Frank [20]).

Therefore, the individual may have monotonic increasing preferences or monotonic decreasing features, which depends on the type of need or motivation (e.g., for the individual, less pollution is better, what means monotonic decreasing preferences). Thus, in conclusion, the decisions made by the agent have as a goal the improvement of the actual state (intending to reach his self-interest).

Lastly, it is assumed that the individual has the cognitive ability to embrace all available information, and to process it in a way that will help him on the course of a decision. In line with this sentence, new pieces of information are automatically processed in order to increase the expected utility of his choice. However, it is important to note that a failure on the information processing can occur only as a result of an asymmetry of information (Silva *et al.* [4]).

[III] THE HOMO NEUROECONOMICUS - CONTRIBUTIONS BASED ON EMOTIONS AND NEUROSCIENCE STUDIES

The latest empirical studies made by the neurosciences and especially by neuroeconomics have brought some new evidences about the individual behavior, notably, in moments of decision-making and choice that can be resumed as a critique to the rationality postulate on economics.

Nevertheless, the purpose of this paper is not to assume that the majority of the economic theories based on the rationality postulate are wrong. By doing that, this study falls in naive falsification, because one piece of evidence cannot make a group of theories automatically inadequate (Blaug [21]).

3.1. What is wanted and what is chosen: the reasons beyond possible anomalies

The orthodox rational economic theory postulates that every person has a stable and well defined system of preferences, hierarchically organized by the expected utility of each option in the presence of different needs and motivations. However studies involving the role of dopamine processes on reward have proven that this sentence is not so rigid.

Dopamine has been seen as the measure to value choices that are made by humans and animals. Mesolimbic and neostriatal projections are triggered in situations and by choices that provoke stimulus, like primary' stimulus (food, sex, drugs) and secondary reinforcers (that highlight the stimulus), that are associated with high levels of pleasure. Dopamine systems, in these cases, act as mediators (also known as the hedonia hypothesis) working on phases of motivated behavior, in anticipation to a given choice (see Berridge and Robinson [22], Panksepp [23] and Phillips [24]).

One other function of these systems is related to the attribution of incentive salience (highlighting the possible reward) on given decisions. This hypothesis suggests that the reward of a given choice can be viewed in terms of what is "wanted", and what is "liked" (see Berridge and Robinson [22]). Both wanting and liking can be viewed as two different mental processes that may have implicit different rewards. Also according to this hypothesis, when dopamine function is activated, this can be seen as similar to grab the attention of the individual to a given thing (liking). However, to be wanted, other types of evaluations must be involved. Dopamine role is seen as a mean to highlight a given option. Nevertheless, it is important to note that things and options which have an emotional value have a stronger and quickest activation of dopamine, which arouses attention and makes a given incentive more salient choice (see Berridge and Robinson [22] and Phillips [24]).

For example, in the studies of Phillips [24], it is stated that dopamine is triggered before a given meal, i.e., before making a choice. The dopamine system is activated before a pleasurable reward. However, if the choice ("wanting") is coincident with the desire, the incentive will remain high (which is translated in high dopamine levels), but possibly not in the previous levels.

Other studies conducted by Schultz and colleagues, showed that dopamine neurons discharge in response to the predictive reward, and not in the moments on usufruct of the reward (Berridge and Robinson [22]).

Impulsive reactions can be triggered by these systems of incentive salience, which may lead to a reversal of preferences. For instance, a person addicted to drugs has as a first order preference the avoidance of the consumption of these substances in order to preserve good health. However, in the presence of an opportunity to consume drugs, the dopamine systems are triggered in a high way, what will highlight the salience of the reward. This can imply a change of preferences between good health and the pleasure given by drugs, even if in a short time period (see Berridge and Robinson [22] and Kiyatkin and Stein [25]).

In conclusion, on cases as the example presented, preferences can mutate, invalidating the stability of the set of preferences and violating the postulate of rationality.

3.2. A potential violation of the rationality postulate on social environments

"Approaching and avoidance" is a balance in order to which a human being has to deal almost every day, and that derives from living on society.

This balance, based on evidences presented by several studies, can be mediated by oxytocin, a nanopeptide produced within the hypothalamic nuclei that modulates these same processes and facilitates the social behavior mediation (see Petrovic *et al.* [26] and Lim and Young [27]). Oxytocin helps the individual to emotionally understand others and to analyze their expressions in order to evaluate the kind of action to be taken mediation (see Petrovic *et al.* [26]).

However, it is important to note that, based on the study of Wicker *et al.* [28], it is indicated that visual stimuli (generated by expressions of happiness or disgust in other individuals) may trigger' actions of approaching and avoidance, possibly mediated by the Insula and the Cingulate Cortex processes (and not influenced by oxytocin).

However, the general ideas transmitted on several studies indicate that an agent captures the emotions demonstrated by others and activates the same emotion inside of him if the feeling is not new. This last point acquires a major importance because, if a person has not felt that emotion in the past, then it will be almost impossible to realize its importance when is felt by another person. On the studies conducted by Phillips *et al.* [29], Adolphs [30], Wicker *et al.* [28] and Krolak-Salmon *et al.* [31] was possible to prove that an individual copies the emotional state of others (and experiences the same feelings) in cases in which the individual has felt a given emotion in the past, presented in a given moment, by another person.

These evidences can launch a new hypothesis. In social environment, if an agent holds, a priori, a defined set of preferences, he is prepared, almost in a rigidly way, to make a decision about. However, on the moment of decision, if he is standing ahead of a situation involving more actors, and these actors are expressing emotions of disgust towards a possible option, then it is probable a change in the decision to be made by the agent, even if this option was in the top of his internal scale of preferences. The same can be applied on inverse situations, when the agent perceives a favorable emotion felt by another individual (or individuals).

This hypothesis can imply the violation of the postulate of rationality, because a change in the expected utility of a given option may occur, and this will modify the order of preferences of the agent.

3.3. The role of emotions on the process of decision-making

Economic and financial sciences in a general way have undervalued, across the years, the importance and role of emotions in the process of choice and decision-making. The economic agent, denominated as *homo economicus*, bases his actions in a well defined process of rational choice, wherein the decision is made, in a direct way based on the expected utility of the reward. Because of that, emotions are seen as cognitive bias that, in the moment of choice, can divert the agent of the rational path.

However, in the latest years, studies made essentially by Bechara [32, 33] and Damasio [34, 35, 36, 37] demonstrate that emotions are an intrinsic process on the decision-making, and they play a key role on the maximization of the agent's choice. To introduce this theme, two clinical cases studied by Damasio [34] are presented. Despite some critiques to the findings of Damasio and Bechara, mainly made by Gazzaniga *et al.* [38], it is assumed that these theories fit well on the purposes of this paper.

The first one is related to an individual named Phineas Gage. He was working on the construction of a railroad, when he had an accident, when trying to detonate a pile of rocks. In the accident an iron bar was projected into his face, entering on the left side of the face and getting out by the top of his head. With the resources of today it is possible to know that this situation caused a lesion in the Ventromedial Prefrontal Cortex, and that the other brain lobes were intact. He didn't die and although resumed his normal life, however with dramatic differences into his behavior. The balance between intellectual and impulsive sides was ruined, and he became unpredictable and indecisive, with the display of few emotions. Countless plans were made only to be easily abandoned.

The second one refers to an individual named Elliot by Damasio, who had Meningioma. He was treated surgically by

removing the frontal lobe tissue. However, a lesion in the cortical region damaged the Ventromedial Prefrontal Cortex. Despite the good recovery, he, like Phineas, was never the same person, exhibiting a small number of emotions, what was a result of the poor access to the social knowledge, which is essential to an advanced reasoning. Consequently, he was unable to make efficient decisions, and the procrastination got something usual. On both cases, it is possible to conclude, essentially, that there is a big difference on the individuals before and after the accident based on the consequent difficulty to express and feel emotional states after the accidents.

An emotion, quoting Bechara and Damasio [39], "is defined as a collection of changes in body and brain states triggered by a dedicated brain system that responds to specific contents of one's perceptions, actual or recalled, relative to a particular object or event". On the cited cases, and in others related both with lesions on the Ventromedial Prefrontal Cortex, as also in the Amygdala, basal ganglia and anterior cingulate cortex, patients show a diminished emotional profile, and limited access to social emotions (closely related to moral values), which leads to inefficient decisions (or the procrastination of some), deficient planning and difficulties on conducting social relations, despite the maintenance of general intelligence, logic reasoning and knowledge (see Bechara and Damasio [39] and Koenigs *et al.* [40]).

The presented profile can be explained with the resource of the Somatic Marker Hypothesis. Somatic states (i.e. internal emotional states) are triggered by primary inducers (innate stimuli, like the fear for something painful or harmful) and secondary inducers (generated by thoughts and memories about stimuli that triggered primary inducers), which makes decisions faster and effective. In cases on which the decision making requires evaluation, the somatic marker classifies possible decisions, as good or bad. However, on the cases presented, somatic signals are interrupted and it is difficult to the individual to classify the expected return of the choice, resulting in indifference to future consequences (see Damasio [34] and Buttman and Allegri [41]).

According to some empirical studies, dealing with gambling tasks (like card games), conducted by Bechara *et al.* [42], Bechara, Damasio and Damasio [43], Bechara *et al.* [44], and Koenigs *et al.* [40], individuals with lesions on the Ventromedial Cortex have more utilitarian judgments and act more according to the economic and financial doctrine of rationality and optimization than normal individuals.

They also prefer choices that involve more risk, without taking any considerations about the future outcomes, and do not express difficulty on more emotional and stressful decisions, which imply more inefficient outcomes in a utilitarian perspective. One explanation for these results lies on the fact that in the process feeling a given emotion can help perceiving the risk, especially if that emotion is not new, and that situation

can modify the probabilities calculated by the individual and help him obtaining a more efficient choice.

Naturally this context can imply that the set of preferences is not rigid and well defined, because it can mutate in response to somatic signals, and because every person has somatic signals that are classified by the somatic marker in different ways (depending on the signals, especially, if they are triggered by a secondary inducer).

3.4. Different features of the memory and his "tricks"

One of the main features of the postulate of rationality in uncertainty refers to the fact that the economic agent possesses all available information; that he can process quickly new pieces of information; and that he can use them correctly to make the best decisions possible in order to maximize the expected utility of a given choice, making valid the proposition of monotonic preferences.

However, to understand if this premise is true, it is necessary to comprehend how the memory processes are structured.

The memory can be divided into two types of processes, that however have strictly connections. The memory that is used on a conscious way is called operative memory (or short-term memory), a limited processor that is used to face immediate problems (that requires the mechanism of reasoning) and that creates and manipulates symbolic representations (see LeDoux [45]). However, in this general process only a limited quantity of information may be maintained (within a limited time). For example, if it is required to memorize a given number, let's say 685291, and next we need to stop, and to count down from 81 to 73, every two, if than is necessary to remember the number firstly mentioned, the most likely is not to remember it. This happens because our mental operative set is extinct to face another task (counting down, every two numbers).

The other type of memory process is the long-term memory, which retains past experiences and information. However, it is important to notice that these pieces of information are saved in a scale strictly related to the importance and impact of these moments in the past (see LeDoux [45] Brown and Kulik [46] and Christianson [47]).

The operative memory does not depend exclusively on the present. It is a partial product and dependent from the long-term memory. If an individual sees an object, like a chair, the visual representation is not enough for the recognition. First of all, this object must grab the attention of the operative memory and next, when the visual stimulus is recognized by the long-term memory, the object is identified. The scheme presented is known as the descending process, from the present to the past (see LeDoux [45] and Kosslyn [48]). There are, however, several considerations to be made about this scheme.

Not all past experiences and information are remembered in the

same way, and the somatic signals associate to each piece of information can determine its importance and the details that were kept. However, the intensity of the somatic signal implicit in the saved memory can bias it, whereby the kept details depend on several factors present at the time of the assimilation of the information (see Christianson [49]). The focus and the emotional state at the moment of the evocation of the memory or information can influence the recall. Because of that, when recalling past experiences, several simplifications, additions, rationalizations and omissions are made, what indicates that the agent includes the expectations of that time in his memories, which can change the real content of the information (see Bartlett [50]). Also, the memories details are more easily remembered depending on the mood of the individual (Bower [51]). Because of that, the individual can have higher probabilities of remembering a good memory when he is in a good mood.

By this way, it is easily noticeable that is not simple to accept the fact that an economic agent can process all the available present and past information. Because of the referred limitations, the economic agent depends, in a large scale, on the connection between the memories and information retained and the somatic signals associated, which allow to give more importance to emotions independently they are related to the present or to the past. On the other hand, the limited capacity of the operative memory makes difficult to calculate probabilities in a very dynamic environment (like the financial markets, for example).

[IV] CONCLUSION

This paper aims to address the validity of the postulate of rationality on the economic and financial theory. The main purpose is to discuss some of the rationality main features and to analyze them under the light of developments achieved by neurosciences in understanding the decision-making process. Essentially, from this study it is possible to highlight that:

- Our brain reacts in anticipation to a possible reward, and because of that a mutation in the preference order and subsequent reversal of preferences can happen;
- In social environments, the individual can understand and almost "copy" feelings and emotions from others, what may change several preferences and utilities;
- Emotions are a key feature of decision-making; providing internal information what can imply the maximization of a given choice;
- Operative memory is limited and can be biased by information belonging to long-term memory.

Following these findings, the construction on a more realistic profile for the economic agents, without a stable set of preferences, monotonic preferences and perfect capacity of information processing, represents an objective to be considered on future investigation on the game theory area.

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CONFLICT OF INTERESTS

The authors declare no conflict of interests.

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