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**LIMITATIONS ON THE PERSPECTIVE OF REPRESENTATIVE ECONOMIC AGENT:  
AGENT BASED MODEL'S ALTERNATIVE**

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**Abstract**

Economic Science emerges from the questions about the behavior human, conflict and social order. Smith, preoccupied with the complexity of social relations and economic phenomena, point out the individual as basis of Political Economics. For the author, social and economic order are maintained in function of the singular behavior of subjects in internal conflict between the search for self-interest and the necessity of social acceptance. A superficial lecture of his work, however, gave the basis of the development of neoclassical economic approach and the simplification of the individual and economic order, with objective to provide predictions about the phenomena, ordered by general and simplistic laws of operation. The *homo economicus*, caricature of the selfish subject of Smith, with unbounded rationality, homogeneous and self-interested, is the central of the economic order, static, in equilibrium and universal, like the perfect world of Newton, symbol of modern science. However, the simplistic model of individual as central to the neoclassical theory and economics mainstream implicates in difficulties to apprehender the economic phenomena, on a complexity and real world. The agent-based model consider the Economy as complex and dynamic system, in constant evolution, based on the mutative and interactive economic behavior. Through computer simulations, this model generate scenarios based on the change of rules in function of the adaptation and evolution of interactive individuals. Furthermore, consider the individual bounded-rationality and heterogeneity, unbalanced and instable environment, with maintenance of mathematical instruments, search precision, objectivity and robustness. This work aims to present the formation and evolution of Economic Science and the figure of representative economic agent, basis of the Neoclassic Economic. Next, is exposed the agent-based model as methodological alternative for Economic Sciences. Its recognizes the limitations of the economic representative economic model and the incipience of the complexity perspective, however, is fundamental the dialogue and review of economic basis, in reason to best comprehend the economic phenomena on a complexity and real world.

Key-words: Economic Science; *Homo Economicus*; Complexity; Agent Based Models.

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## INTRODUCTION

The conception of the individual in Economics is fundamental for understanding the economic phenomena in different approaches. We have in Adam Smith a reference about the comprehension of social being in its motivations in gaining welfare, and individual importance in broader contexts.<sup>1</sup> Based on a precipitated lecture of *Wealth of Nations*<sup>2</sup> is attributed that the individual search for self-interest on a society formed for egoist men, is the key for economic progress (Smith, 1996).

However, a more dedicated lecture about the author's theoretical contribution corresponds to study "Theory of Moral Sentiments" and the position of social being in society, harmony and conflict between individual and collective interests. The feeling of social acceptance and collective gratitude stimulates the singular interests to converge to a point promoting common welfare in capitalist society (Smith, 2006).

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<sup>1</sup> It is recognized as Adam Smith's great contribution to social relations, in comparison to previous theorists, the dissociation of the relationship between well-being and power. The greater the division of labor in a complex capitalist society, the greater the qualitative gains to the simplest of the workers, nonexistent to landlords in pre-capitalist societies with precarious division of labor. For a more in-depth discussion of Smith's theoretical contribution to individual perceptions, motivations and social gains, see Cerqueira (2004) and Boff (2014). For an alternative perspective on Smith's economic and social conception, see Ganem (2000) and Sen (2010).

<sup>2</sup> There's a great discussion in the history of economic thought about Smith's contribution to the economic agent, comparing his two main works, *Theory of Moral Sentiments* and *The Wealth of Nations*. This debate recognized as "Das Adam Smith Problem" raised by economists of the German Historical School questions the motivations of a benevolent being who acts by a feeling of social sympathy in contrast to the self-interest of the selfish economic agent raised in the work *The Wealth of the Nations*. The pertinence of the discussion and the quality of the arguments presented is acknowledged, and the unity of his thinking and non-dissociation of the two concepts is reiterated, which requires a more thorough and virtuous study of his work. For more targeted reading, we recommend Ganem (2000; 2002) and Boff (2014).

The proposed “scientification” of Economy, grounded in solid and widely accepted scientific fields, under the positivism, instigated the simplistic and generalist interpretation of Smith's work, in the conception of selfish subject and self-organization of the market by the mechanism of the invisible hand. The individual, in its complexity and uncertainties, has been reduced to generality subject to of logical formalization of an ideal model of economic behavior.

Maurice Lagueux (1997) argues that the rationality's idea adopted post Marginalist Revolution, based on precipitated view of egoist man on Smith (1996), was the foundation of contemporary economics. Menger (1983), lined on Stanley Jevons (1983) and Léon Walras (1996), formalizes the conception that individuals behave in way to maximize their satisfaction, in an exchange environment.

This agent, *homo economicus*, presents characteristics irrealistics, subject to reviews, about the capacity to explain real economic phenomena (Yaman; Yoneda; Tsutsui, 2012), witch suggest the need to reformulate its conception in order to better inform economic studies.

The 2008's global crisis renewed the discussion about the effectiveness of the neoclassical models of formalization and economic forecasting. The Agent-Based Model emerges as a methodological alternative for formal analyzes of the economy as a complex and interactive system. The model proposes to reconcile the proposed traditional mathematical formalization with distinct perspectives of economic subjects, on micro and macro-dynamic aggregates.

This paper aims to show the representative economic agent model, *homo economicus*, critically, and propose to question: what's the limitations and methodological alternatives to representative economic agent, give the agent based model, from the complexity perspective?

Besides this introduction section and final considerations, this paper is divided in three parts. The first deals with the formation of Economics as a science and theoretical foundation of the representative neoclassical economic agent. The second section presents critical perspectives on the traditional conception of the economic agent. Then, the exposure of the Agent-Based Model is synthesized as an alternative proposal of formalization in economics based on another reasoning of economic agent.

## **1 ECONOMIC SCIENCE AND REPRESENTATIVE ECONOMIC AGENT CONCEPTION**

Gentil Corazza (2009) argues two different views about the nature and evolution of Economic Science. First, consider the impossibility prevision of emergence of Economy, in that it conforms as a construction of extensive and increasingly true knowledge to result in a single scientific. The second perspective point out Economic Science as a methodological structured body and with a specific object only became possible on capitalistic society, when social relations of labor and trade began to have a specific objective beyond the pure satisfaction of the Human needs.

Anyway, Economy is relatively recent compared other field of scientific research. Adam Smith, initial founder of the Economy as a science on 1776, relied on incipient and non-consolidated epistemological foundations, like the English cleric John Hales (1584 – 1656) theory that economic relations go ahead to the moral rules valid to individual behavior (Santana; Santos, 2011).

The position of the individual at the center of knowledge and responsible for his actions is a mark of the scientific, political and cultural revolution of the Enlightenment and Renaissance - milestones of the modern era. Smith does not echo alone, it is recognized the joint importance of Nicolau Maquiavel, Thomas Hobbes and John Locke for building the individual in Political Economy. Maquiavel exposes the pettiness and selfishness characteristic of human beings in political demonstrations in power disputes. Hobbes, in *Leviathan*, points to the chaos arising from the free sociability of individuals driven by destructive passions under the social domain of *homo homini lupus*. Locke, in turn, contributes significantly to Smith's legal conception of guiding state, in defense of private property and fundamental individual rights (Luz, Falazanca, 2013).

The political character of the Economy and the social consideration of the individual, raised as the crux of the new knowledge, is evident. The foundation of the active subject in economic relations, analytically grounded by Smith, refers to a theoretical and historical construction of a being in constant social change due to his interaction with other subjects and the emergence of social structures beyond individual wills. Selfishness and individual pursuit of satisfaction, parallel to a common social feeling of solidarity and gratitude, would configure the collective functioning of a market economy, beyond individual interests themselves (Smith, 1996; 2006).

Angela Ganem (2002) emphasizes the centrality of individual behavior in Adam Smith's economic analyzes, in the search for an understanding of the universality of his passions, in his desire to improve his own condition and his ability to generate collective gains in a capitalist society. In admission to the historicity of moral relations and the dynamics of behavior, Smith attributes analytically the micro-foundations of a collective order, based on the invisible hand of the market.

Hugo Cerqueira (2004) recognizes that Smith's concern with the individual isn't in itself a novelty. However, the analytical degree attributed by the Scottish Philosopher to the positioning of the individual in society is highlighted. The connection between particular interests, in conciliation of self-love and collective phenomena, as a mechanism for generating wealth in a society divided by labor, in an empiricist perspective, highlights Adam Smith and the nascent Political Economy as an autonomous field of scientific investigation.

There is evidence a rupture with the theological thinking of organization and representation of social phenomena, from the moment in which man is attributed responsibility for his actions and the dynamics of the material world. Married to the humanist ideas of the Renaissance and Enlightenment, Smith dwells on moral and political philosophy, which understands man as subject and object of knowledge, in concern for the social order and the conflicting individual passions (Ganem, 2000).

The philosophical and theoretical contributions from Adam Smith for understanding the nature of social phenomena had incited relevant debates in history of economic thought. The divergence between the conception of individual discuss on Theory of Moral Sentiments and the Wealth of Nations, incited by Bruno Hildebrand and Karl Knies, old Germany History School theorists, became known as "*Das Adam Smith Problem*". For these authors, there is an inconsistency between the two works, in which an idealistic and naive philosopher exposed a society formed by subjects influenced by sympathy in the first book, in confrontation with a materialist philosopher who understood the society conformed by selfish subjects, in discontinuity of ideas (Boff, 2014).

Emmanuel Boff (2014) advocates overcoming the problem at this point, since the motivation of both subjects in Smith occurs through the search for self-love, which reconciles self-interest, with the need for collective acceptance and sympathy of the other subjects in society. The manifestation of the problem is precipitously perpetuated by the defense of the Smithian subject of the Wealth of Nations, logical and rational-maximizing, such as the *homo economicus*, in an attempt to "scientificise" economic science according to reductionism and generalism, milestones of modern science.

Keep this in mind, in an attempt to dissociate itself from morality and philosophy, in methodological attachment to modern science, Economics was mirrored in solid fields of investigation such as Physics and Mathematics. At the end of the nineteenth century, authors like William Jevons and Leon Walras proposed the formalization of economic environment in ideal conditions and logical operation, analogously to the hypothetical world without friction of Newtonian physics. The equilibrium would be based on individual rationality, which assured the economic agents perfect and predictable behavior (Prado, 1994; Lagueux, 1997).

Colin Camerer (1999) questions why the approach of Economy approximates of physics and not of psychology as a science responsible for understanding human behavior. Both sciences were consolidated at the same time and were based on solid sciences, with different methods. Economics was based on physical formalization and Psychology clung to mathematical logic. Therefore, fields

of research on similar objects have distanced themselves as a result of different methodological foundations. The fact that there was no psychological support for the agents' behavior gives way to the perception of a less normative tendency in economics, with a view to greater objectivity and equilibrium, in a scenario of hypothetical stability, such as Newton's ideal world.

Milton Friedman argues that economics should be a positive science, that is, one must worry to explain the phenomena as they are and not question how they should be. By means of the objective simplification of reality, he must be able to provide a system of generalizations that attempts correct predictions about the consequences of change under any circumstances. In this way, as less detailed, in detachment from realism, more apt to the accomplishment of general objective predictions (Hausman, 2007). Friedman gives the positive and non-normative character of economic science, distanced even more the Economics of Psychology, in what concerns the understanding of the rational behavior of the individual (Camerer, 1999).

From this proposal of science, from the "marginalist revolution", was proposed to idealize individual behavior in order to provide a simplified understanding of reality. The law of diminishing returns of land, Ricardo, is generalized to all sectors of the economy and their own individual behavior. The ideal individual behavior is motivated by maximization of utility, decreasing marginally, given the limited resources available (Sraffa, 1998).

McCloskey (1983) states that the positive character of behavior based on utility maximization is considered by most economists to be the official method in Economic Science. It is, therefore, a methodological obstacle to the advancement of alternative proposals, in that it is used as a rhetorical argument for the validity of such precepts, in function of the objective mathematical logic presented. This section presents the main characteristics of this agent from the perspective of neoclassical economics.

### 1.1 *Homo economicus* as economic representative agent

Herbert Simon (1978) argues that, given scarcity conditions, the central concern of economics is based on the rational allocation of finite resources and that the concept of rationality has a different economic meaning. In pursuant, economic analysis aims to point out the results of rational choices, while other social research fields are concerned with rational decision-making processes. More over, in segments<sup>3</sup> of the economic mainstream<sup>4</sup>, rationality is interpreted as utility maximization.

The rationality principle is the idea that the people act rationally in sense to maximize its utility, according its objectives. Even though referent to neoclassical theory, this principle sometime is confusing assumed as basis of all Economic Science. According this theory, this principle control the general behavior of individuals, then, the homogeneity indicates the rational-maximizing agent as economic representative agent.

Yanis Varoufakis (2002) defines this behavior as instrumentally rational because the rationality is a tool to maximize the utility of the individual. Therefore, the agent is greater rational

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<sup>3</sup> Same mainstream segments denies the perspective of rationality as utility maximization, at time that are group with internal inconsistent, composed by ideas that could be contrasts between itself, but both influents and sociological acceptable in elite academy. As example, we have New Institutional Economy, with North, and Game Evolutionary Theory, both growing in the ends of XX century and denies the objective rationality formalized by utility functions (Dequech, 2007).

<sup>4</sup> Dequech (2007) defines economic mainstream as a set of ideas sociologically acceptable, defends by dominant groups of the elite of scientific academy on a give epoch, showing influence under other lines of thought. To know more about the sociological characteristic of dominant ideas, see Colander, Holt and Rosser (2004).

how much it is capable to use its abilities to can what it wants, give capacities and constrains. Logically, is less rational if lose opportunities to maximize its satisfactions.

Simon (1976) defends the existence of two kinds of rationality: substantive and procedural. The behavior é substantively rational when refer only to itself and to realize own goals, in function of constrains. In other way, procedural rationality exists in function of a specific process generator and not involves entirely the agent.

Gary Becker (1962) characterizes the *homo economicus* as an agent endowed unbounded rationality, timeless psychology, calculus capacity and unlimited thought, hedonistic motivation and able to give order to its utilities and preferences, formalized by mathematical utility functions. Indeed, the utility-hedonist principle search action for imediact satisfaction of individual (Augusto, 2010).

Yamane, Yoneda e Tsutsui (2012) characterizes the *homo economicus* as a self-interested subject with unlimited cognitive resourses and perfect self-control. The rationality is measure for the logical thought based on scientific knowledges developed by the individual to decide how to act. In synthesis, Gomes (2012) describes the representative rational economic agent as an individual who search maximize it utilities in function of monetary constrains. The utility function and maximizing-function are mathematical formalizations that show the decision behavior of the agent between the present and the future, ordered serially on preferences.

The traditional model of representative rational agent, proposed by the neoclassical economists from marginalist revolution, although simple, had same positive points. Friedman defends the simplistic models because they are more objective than real models and not delimit space or time, turning easy correct previsions (Hausman, 2008).

Becker (1962) affirms the rational-maximizing agents model tend to be better than non-rational behavior because represents the medium behavior of agents, according to Friedman. In addition, the figure of representative agent must persist while the Economics fundament itself in conception of anonymous individual maximizing agent (Kirman, 1992).

It's possible to understood that the simplification of Economy on a static state, in equilibrium, with the central figure of homogeneous agent, rational-maximizing, *homo economicus*, is acceptable on orthodoxy<sup>5</sup> academy, although its known limitations and exception of some schools of thought. The difficult to accept new perspectives occur in reason the traditional method be simple to provide previsions, and in function of rejection of mainstream scientific community for more plural perspectives.

It's necessary emphasize existence of a set of schools on Economics mainstream that denies the unbounded rationality and self-interest of the individual like homo economicus. However, the prestige and influence capacity of the dominant academic research show, sometime, an barrier to pluralism, specially when the rationality or the mathematical methods are denied. Exceptionally, we have the Behavior Economics, that go on into the mainstream, but confronts with neoclassical simplification, approximating to realism.

Next, its show the differents perspectives to tradicional representative rational economic agent model, and the idea of rationality itself.

## **2 CRITICAL PERSPECTIVES TO THE REPRESENTATIVE RATIONAL AGENT**

The main criticism of the traditional model of economic research lies in its conception of the individual as a rational-maximizing agent endowed with information and unlimited reasoning. Eleutério Prado (1994) agree with Herbert Simon in his defense of limited or procedural rationality.

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<sup>5</sup> Dequech (2007) understand Neoclassical School, although there are controversies, can be considered orthodoxy.

Limited to the extent that there are costs for acquiring information, which are not free, and procedural because they depend on the deliberation of processes and rules of behavior. From this point come the other questions of economic functioning, such as the perspective of balanced markets.

This section presents theoretical perspectives in counterpoint to the conception of representative rational economic agent in its three basic aspects, according to Becker (1962) and Yamane, Yoneda and Tsutsui (2012): unbounded rationality, self-interest and homogeneity. The following topics present a synthesis of the alternative proposal to approach the behavior of the agent in the economy, in each one of said aspects.

## 2.1 The representative rational agent and the bounded rationality

The critical perspective on rationality had its main exponent perhaps in the figure of Karl Popper. Through a critical Socratic stance, of dialogue to the detriment of knowledge as a dogma, Popper (2012) questioned the unlimited and universal rationality of the traditional agent of neoclassical economics. Lagueux (1993), however, states that although he considers it false, Popper (2012) defends the principle of rationality in situational analyzes.

The rational action of the individual takes place in consonance with the situation in which it is inserted, in such a way that apparently psychological factors are translated into situational factors. Agent preferences, technology and features arranged constitute the agent's situation and motivations. A standard behavior derived from a given situation is deduced and from this a rational principle is established that indicates the appropriate behavior given the similar context (Marin; Fernandez, 2004).

Bruce Caldwell (1991) states that Popper's situational analysis is individualistic, but not psychologistic. The individual bases his behavior on situational factors and not inherent in his psychological nature. The individual behavior is based on situational factors and aren't inherent in his psychological nature. Marin (2008) suggests that the model of situational analysis is mechanical and abstract, and its application to all social sciences is valid, insofar as the situation and purposes and knowledge involved are determined, due to the specific conditions and adequate rationality. The author states that situational analysis is proposed as the basic methodology of the social sciences, through the identification of the "zero principle" from which individuals act appropriately and distinctly given each different situation.

From another perspective, the rationality of the economic agent is bounded, given its own biological limitation. The inability of the human being to process information in full reasoning, as well as the uncertainties that surround it, stemming from the inability to anticipate the future, limit it to only exercising procedural rationality, in processes of adaptation and faulty predictions about phenomena that have not yet occurred (Prado, 1994; Simon, 1976).

Burrhus Skinner (1953) denies the perspective of rationality of the individual as a result of an inherent characteristic of the agent, as the perspective of *homo economicus* points out. According to the behavioral analyst, the agent relies on control behaviors, in response to environmental contingencies, with responses from individual learning. Rationality is dynamic, not unique and static as the mainstream indicates, with emphasis on the Neoclassical Economy.

Wade Hands (2017) discusses the rescue of the representative agent in economic theory, stresses that there is a broad set of economic research that suggests that rationality is more a feature of many types of institutions - particularly the market - than individual agents. Such research shows that it is possible to maintain mathematical optimization tools as much as the optimality of the final result, without involving (potentially problematic) the individual rational agent.

For Destarte Oliven and Rietz (2004), empirical experiments in the electronics market in Iowa, United States, indicate that agents adopt supposedly unreasonable behaviors, with "clear errors" in dissonance with the *homo economicus*. However, it was noticed that this behavior did not negatively influence the efficiency of the market, contrary to what the neoclassical theory points out.

Hall and Hitch (1939) question the rationality of economic agents by taking the example of firms in a competitive environment. With an empirical study, they found that companies set their prices by applying a mark-up rate on average costs rather than marginal costs of production. "Non-rational" behavior was predominant over the behavior of the representative rational economic agent.

Despite the attribution of the full rationality perspective to Smith's ideal egoistic behavior, the author himself reiterates the limitations of human rationality due to the lack of self-control and mastery over thoughts and actions, influenced by the passions and personal particulars of the agent (Smith, 2006).

When we are about to act, the eagerness of passion will seldom allow us to consider what we are doing, with the candour of an indifferent person. The violent emotions which at that time agitate us, discolour our views of things; even when we are endeavouring to place ourselves in the situation of another, and to regard the objects that interest us in the light in which they will naturally appear to him, the fury of our own passions constantly calls us back to our own place, where everything appears magnified and misrepresented by self-love. (Smith, 2006, p. 138).

It is understood that there is a limitation in the very capacity of the human being to act rationally due to the emotions that influence his actions and hinder the objective and impersonal action. When Smith (2006) cites that everything appears poorly represented by self-love, it transpires the bounded rationality and subjection of the individual to the emotional burdens that surround him in his false perspective of self-interested actions.

## 2.2 Representative economic agent and self-interest

It is emphasized that in the traditional economic literature, the critical perspective on the figure of the representative economic agent, *homo economicus*, falls emphatically on its characteristic of unlimited rationality with objective preferences and primary motivation for the self-interest, configuring itself few works<sup>6</sup> referring to non-Homogeneity of the economic actor. Consequently, the critique is to come, multidisciplinarily, mainly in Psychology.

Among the works that deserve special mention are De Figueiredo et al (2016), Nelson (1996), Buss (2015) and Skinner (1953). Buss (2015) presents, under the bias of Evolutionary Psychology, the relationship between gender differentiation and the social conformation of individuals, such that heterogeneity manifests itself in psychological interests and manifestations of action of individuals.

For Skinner (1953) the original individuality is outside the organism. The behavior of the subject is conditioned by the history of contingencies, or experiences, in a construction process. According to the author, different subjects are conditioned in a singular way by virtue of the different histories of their experiences. It considers, therefore, the individuality outside the organism insofar as it is formed from the relations that the individual establishes with the environment and with other individuals.

For Consonant Julie Nelson (1996), traditional Economic science defines the representative economic agent in socially constructed patterns as masculine. The emphasis on rationality, objectivity, domination, and control over nature differs from female behavioral attributions such as subjectivity, submission, and connection to nature. Consequently, the homogeneous behavioral pattern does not reflect the diversification of agents and adopts a false universal model as representative.

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<sup>6</sup> Noteworthy are the works of Nelson (1996), Gaffard and Napoletano (2012).

Hausman (2008), based on Nelson (1996), proposes an alternative perspective on economic modeling. The maximizing-rational agent, homogeneous and without interaction with the environment and other individuals, should be replaced by agents with different characteristics. There are not attempt to ignore traditional behavior, rather, to accept that subjective and interactive individuals can also represent economic actors, realistically.

De Figueiredo et al. (2016) admit that the centrality of the individual in economic models reflects the importance of defining his behavior pattern on the realism of the elaborated analyzes. It emphasizes that the existing heterogeneity between actors by age, sex, income and specific membership of social groups conditions them to behavioral differentiations. The non-incorporation of such variables into traditional neoclassical models impoverishes their capacity for analysis.

Spaventa (2009) emphasizes the importance of attention to the heterogeneities of the agents for better comprehend the markets. The non-assimilation of behavioral heterogeneities, asymmetries of information in banking markets, for example, provides robustness to the model, but it significantly simplifies and omits relevant characteristics of reality.

In agreement with Sen (1977) about the influence of commitment on the behavior of economic actors, we can infer that the involvement of agents in certain contexts and social groups shapes their way of acting from the assimilation of internal rules of conduct. In a theoretical analogy with De Figueiredo et al. (2016), commitment not only affects the self-interest of agents, but also affects their heterogeneity as interactive subjects.

It is understood the relevance of traditional models for economic analysis focusing on robustness and objectivity, with the intention of providing accurate forecasts. However, the methodological limitation in the centrality of the representative economic agent is admitted, which differs significantly from empirically perceived human behavior.

Pluralism can enable the absorption of new methodological approaches on the neoclassical proposal of individual. However, a significant part of the scientific community rejects new proposals by virtue of its adherence to mathematical formalization and modeling inspired by physics, under the demarcationist argument that this is the real science, since it is based on logical premises not subject to falsification, by the method of Popper. Goulart, Vasconcelos and Fernandez (2017) discuss the scientific character of Economics, in criticism of the methodology used by the mainstream. They emphasize the criticism of mathematical formalization itself and its use as a criterion of scientific quality, and especially the failure to adequately explore the mathematical instruments to apprehend the complexity of the world, in accordance with deductive deductive logic.

The following section presents a methodological alternative to economic modeling from another agent perspective. Through the communion of the objective and formal proposal of the *mainstream* methodology with critical perspectives to the constraints of the economic agent, we try to introduce the discussion about agent-based modeling. Melo and Fucidji (2016) present the Herbert Simon model for the decision-making process of the agents in complex environments and highlight the agent-based simulation models as instrumental to the analysis of complex systems.

### **3 NA METHODOLOGICAL ALTERNATIVE: AGENT-BASED MODEL**

The academic maintenance of the traditional neoclassical models was due to the rhetorical argument of its efficiency in relation to precise predictions about the economic phenomena. The method of abstraction in modeling with equilibrium, static and homogeneous, efficient variables and rational agents, despite the criticisms and alternatives proposed throughout the twentieth century, has perpetuated itself as mainstream in the main international scientific groups.

The global financial crisis of 2008 put in check the explanatory and predictive capacity of the traditional models of general equilibrium. Models of general equilibrium are grounded in substantive rationality in such a way that all future contingencies can be anticipated, in the understanding of the ergodicity of the economic system and homology between the axiomatically

established model and reality - without empirical foundation (Melo, Fucidji, 2016). Gaffard and Napoletano (2012) define as main failures of the traditional models of general equilibrium adopted until then, ignorance regarding the heterogeneity of agents, agents perspective with unlimited rationality and assumption of equilibrium.

The scientific evolution in the field of computing throughout the second half of the twentieth century allowed the advent of complex instruments for use in various scientific fields. Engineering sciences, biology, physics and areas of psychology have entered into studies of complex systems. The positivist approach, adherence to the theoretical formalization and assumption of equilibrium and homogeneous patterns of behavior deprived the advancement of such methodology within Economic Science (Pyka; Fagiolo, 2005).

Economics can be considered as a complex system, based on Wolf et al (2012). The interaction between heterogeneous agents in dynamic scenarios based on learning from interactions and macroeconomic impacts characterizes economic systems as non-static and balanced. The ABM are interesting instruments for the perception of the macro phenomena from microeconomic aggregates.

John Davis (2014) argues that complex environments are in a constant process of mutation resulting from the transition from old to new rules, because of the capacity of learning and adaptation of individuals. In short, changes occur through the dynamic interaction between agents in processes of self-organization or through "shocks" and changes in the environment, regardless of the interactive processes.

Computational advances in Economics followed another approach. The work of Von Neumann (1971) and Scarf (1967; 1982) with calculations of economic equilibrium, as well as the contributions of Dantzig (1948) in mathematical programming, stand out. These are methodological and algorithmic bases for the further development of the Agent-Based Model (Kirman, 2012). Only in the late twentieth century do the first works by the methodology of the Model Based on Agents, with a view to analyzing Economics as a complex system based on micro fundamentals of interaction between economic agents Asymmetries of information (Gaffard; Napoletano, 2012).

Pyka and Fagiolo (2005) highlight the multidisciplinary character of the ABM proposal. The perspective of Economics as a complex system has methodological similarity to Biology, Physics, Sociology, Computing, Psychology and in a different body of scientific fields. It reiterates the counterpoint established in relation to traditional static and balanced models, which indicates the monitoring of the advancement of the Economy in relation to the advance of other sciences, something not verified by mainstream modeling.

### 3.1 General Characteristics of Agent-Based Models

This point is devoted to a general explanation of the characteristics of the model as an alternative. The main contributions are in Pyka and Fagiolo (2005), Kirman (2012), Wolf et al (2013), Napoletano, Gaffard and Babutsidze (2012), Gaffard and Napoletano (2012). The incipience of the methodology presented here is verified by the contemporaneity of the works and by the lack of uniformity in methods in different approaches in development.

Pyka and Fagiolo (2005) define that ABM work in micro-macro perspective. From the conception of the heterogeneity of the agents and their interaction, patterns of behavior are verified in microeconomic perspective. In turn, the established relationship between patterns impacts on the macroeconomic scenario dynamically. Synthetically, Economics is understood as a complex system of interaction between heterogeneous agents, with impact on macroeconomic aggregates.

ABM use simulation tools to analyze dynamic and heterogeneous economic scenarios. Kirman (2012), in defense of this modeling proposal, argues that traditional models are incapable of representing reality, given their oversimplification. Computational models, by virtue of their great capacity to work with data, allow the categorization of different patterns of behavior in differentiated individuals and creation of dynamic scenarios. They also allow for experimentation, something unfeasible in traditional Economics methodologies.

Napoletano, Gaffard and Babutsidze (2012) argue that ABM presents a challenging modeling proposal. The assimilation of information asymmetries, interaction between heterogeneous agents, formation of expectations under limited information, learning by experience, institutional structures and dynamic behaviors, approximate the abstraction of reality and promote greater instruments of evaluation and prediction of economic disturbances such as persistent unemployment, contagion of non-optimal information, for example, characteristics close to real systems.

The assimilation of elements more complex than those presented in traditional approaches and the negation of the equilibrium perspective due to the charged interaction of uncertainties between heterogeneous agents allow the use of modeling in scenarios ignored by neoclassical economics. The positive character of economics defended by Friedman loses relevance and normativity becomes pertinent in the search for an explanation of economic phenomena.

It is important to emphasize, according to Kirman (2012), the centrality in the concern with the exposition of objective, precise and robust information, with the use of advanced mathematical and statistical instruments. It is not proposed to deny equilibrium models, but to aggregate information in a complex system, while maintaining the proposal to provide accurate predictions about economic phenomena.

The Agent-Based Model presents some limitations or difficulties despite the advances presented. Wolf et al (2012) emphasize the unpredictability of the model and lack of control on the part of the researcher. On the one hand, it represents the impartial character of the analysis, on the other hand, however, it hinders the ability to provide initial hypotheses. The system of probabilities used indicates randomness that can be confused with lack of standard or coherence in initial analyzes.

Napoletano, Gaffard and Babutsidze (2012) point out the difficulty of conformation of the patterns among heterogeneous microelements without the use of neoclassical rationality. The difficulty of perception about the factors that coordinate the decision making of the agent, as well as the unpredictability and lack of standard, make it difficult to falsify, which is not interesting as a proposal of scientific methodology.

It is noteworthy that although the ABM reject the standard models of rationality and individuality, they contribute little to an evolutionary model of individuals (Davis, 2014), which is very due to the methodological prematurity of the models in question and reflects the vast field of expansion for research in complex evolutionary systems of computational simulation.

In turn, due to the incipience of the proposal and the use of complex computational systems of simulation, it is attentive to the difficulty of interpretation of information and assimilation by laymen, due to the lack of knowledge of many economists and other researchers regarding The new methodological proposal presented.

### 3.2 A synthesis: the agent perspective in ABM

The objective of presenting the ABM as a methodological alternative to traditional neoclassical modeling ends in its distinct perspective in relation to the individual, in opposition to the use of the representative rational economic agent model, homo economicus. It is understood that from a new vision of economic subject are found answers to other central problems in the Economy, as the origin of the imbalances, for example.

In a complex environment, the endogeneity of the individual in relation to the world is considered, as it is a component of a larger system, which in turn is influenced by individual agents. It is a mutual process of interaction and evolution through learning. Therefore, the incorporation of the learning dynamics among isolated and self-organized individuals by the ABM is a fundamental factor for the apprehension of economic phenomena from another perspective of the subject. Imbalances can be perceived as structural changes in a constantly evolving environment endogenously motivated and grounded in individuals who are able to organize themselves and modify their own behavior and the environment around them (Davis, 2014).

The individual is characteristically heterogeneous and, from interactions on microeconomic plan, affects the macroeconomic scenario and denies the equilibrium and stability ideas. Kirman (2012) stress that the agents "look for ahead", are dynamics, learn with experiences and react to institutional change and to behavior of other people. The rationality is not a priori, is the product of uncertain and dynamic social constructions.

Wolf et al (2012) highlight the uncertainty about the behavior of the agents. The negation of rationality and equilibrium is formalized in ABM by the use of complex probabilistic systems that indicate patterns of behavior of microeconomic groups. Individuals are thus endowed with limited rationality and act in an unpredictable way.

The individual understood in complex systems by the ABM has limited rationality and differs significantly from the caricatured figure of the homo economicus. The central point is the limitation imposed on individuals by external factors that operate on themselves, in dissonance of the representative economic subject, unlimited in their individuality and endowed with exogenous, constant, consistent and unitary utility functions, without connection to the environment or other individuals (Davis, 2014).

The main advance of the ABM in relation to traditional modeling may be the consideration of the heterogeneity of the agents. The basis of imbalances, information asymmetries, economic policy failures, and institutional inefficiency fall far short of the non-standardization of agents in their characteristics and behaviors. The assimilation of such elements into economic formalizations characterizes a methodological advance over that presented in mainstream academies.

## **FINAL CONSIDERATIONS**

Economic Science arose from the need to understand the motivations of individual behaviors and their relative importance in shaping the social order in a changing society. If possible only with the formation of the capitalist system or even as a result of the evolution of ideas in the process of consolidation, its link with the social transformations and the doubts extracted from the result of human behavior in an anthropogenic and dynamic society is clear.

The scientific knowledge, in its support and social acceptance, was the reference point for incipient manifestations of knowledge, in such a way that Economic Science, by the Neoclassical School, clung to the formalization of the natural sciences and simplified the complexity of the real world in Fragmented variables of predictable behavior and ordered by universal laws, having as main exponent the individual, in the figure of Homo Economicus - endowed with unlimited, homogeneous and self-interested rationality.

The Agent-Based Models present themselves as an alternative methodological proposal to the scientific community, by adding positive points of the neoclassical method and also of the proposals critical to the mainstream. The use of ABM allows, by means of computational simulations, to understand the economy as a complex system and to provide predictions more efficient than the traditional models of equilibrium, by the assimilation of realistic characteristics to the agent and the aggregate in the system. It is understood that the search for pluralism and openness to new perspectives is fundamental, like the one developed in the aforementioned model, for the evolution of science and a better perception of real economic phenomena.

The mainstream and non-mainstream dichotomy, while fundamental to critical dialogue, should not be an obstacle to scientific advancement. It is possible to adjust the positives of the two approaches. Despite the limitation of ABM, the significant advance of its proposal is understood, even if it is replaced by more appropriate methodological instruments through critical dialogue.

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