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Rational Economic Models of *Homo Sapiens*

Abstract: *There is a rich complexity to actual human beings that cannot be captured in totality by any specialized academic discipline because all disciplines, in the process of specialization, focus only on narrow aspects of what it means to be human. Economics takes this reductive approach further. For reasons typically linked to analytical tractability, agents in economic models often behave in ways that are not only simpler but also markedly different from actual human behavior. In this essay, I discuss some of the reasons and justifications behind the choices made by economic modelers over the years. In doing so, I describe how economic modeling has evolved over time and across different schools of economic thought. In particular, I delve into the rational agents and rational expectations paradigms and how those have been challenged by findings from behavioral economics and macroeconomic events such as the great recession. Next, I comment on current practices with an eye towards the future by arguing that rational economic models might require agents with distinctly non-rational behavior. Merely tinkering along the edges to somehow incorporate inconvenient behavioral biases into an expanded definition of rational behavior is woefully inadequate today, especially since the exponential increase in computational power allows modelers to think in terms of simulation models that are not constrained by the traditional problem of analytical tractability.*

1. Introduction

It is hard to pin down a precise definition of economics as the field is broad and ever-expanding. Beckhouse and Medema (2009) discuss several definitions of economics and all of them involve human decision-making either explicitly or implicitly. Beckhouse and Medema (2009) quote Lionel Robbins's definition, "the science which studies human behavior as a relationship between ends and scarce means which have alternative uses," (225) and suggest that it is "perhaps the most common currently accepted definition of economics." (225) Thus, across most definitions and particularly in the most common definition, human decision-making is central to economics; this necessitates a disciplinary view of what it means to be human.

Human behavior is notoriously hard to model. People are diverse and their decisions are influenced by a multitude of ever-changing factors: pecuniary incentives, expectations and beliefs, emotions, morals, cultural influences, social pressures, forces of habit, etc. This complexity is further compounded once we account for direct interactions between humans as well as indirect interactions among humans through institutions such as markets. Economists, therefore, adopt one or more of the following three approaches: (1) avoid mathematical formalism, (2) focus on empirical relationships among economic variables in a manner that minimizes the need for a formal model of human behavior, and (3) make simplifying assumptions regarding human behavior to create tractable models. Mainstream economists have mostly adopted the second and third of the above approaches.

1.1 Approaches that avoid mathematical formalism

One approach that avoids mathematical formalism is praxeology – a method championed by proponents of the Austrian economics school of thought. Praxeology is an axiomatic method of inquiry built on the insight that human action is purposive or goal oriented. This approach involves building theory through axioms rather than mathematical models and associated data analysis. In the words of

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Mises (1998), "There are, in the field of economics, no constant relations, and consequently no measurement is possible… Different individuals value the same things in a different way, and valuations change with the same individuals with changing conditions." (55-56) Moreover, praxeology, as applied by economists of the Austrian school, is critical of the reductivism demanded by mathematical formalism. According to Rothbard (2011), "Without setting forth the comprehensive Austrian case against mathematical economics, one point can immediately be made: let the reader take the implications of the concept of action as developed so far in this paper and try to place them in mathematical form. And even if that could be done, what would have been accomplished except a drastic loss in meaning at each step of the deductive process?" (62)

Another approach borrows from the field of history. Rather than systematize, forecast, and generate quantitative models of economy-wide consequences, this approach shifts the focus to important events without invoking generalizable mathematical formalism. A third approach adopts qualitative methods of analysis, often borrowed from fields such as sociology. Acclaimed sociologist Cameron (1963) highlights the importance of non-quantitative approaches thus: "It would be nice if all the data which sociologists require could be enumerated because then we could run them through IBM machines and draw charts as the economists do. However, not everything that can be counted counts, and not everything that counts can be counted. Often, we must use nonquantitative methods…" (13)

While these approaches have their appeal, I believe quantitative techniques are important too. They allow us to identify tradeoffs explicitly and therefore facilitate more informed decision-making. They also help enforce scientific discipline, facilitate clear thinking, and enhance the scope for falsifiability.

1.2 Approaches that focus on empirical relationships among economic variables in a manner that minimizes the need for formal models of human behavior

Econometrics, the sub-field within economics that deals with data analysis, includes many approaches where formal models of human decision-making are either entirely absent or reduced to very general mathematical functional forms. Techniques within econometrics can be classified based on how reliant they are on *a priori* modeling assumptions, which include, either directly or indirectly, assumptions regarding human behavior.

1. On one extreme, some techniques, such as unsupervised machine learning, make no assumptions about human behavior. This technique tries to uncover patterns and relationships in the input data without much in the way of restrictions or assumptions imposed by the data analyst. Similarly, several non-parametric techniques such as kernel density estimation or k-nearest-neighbors involve very few assumptions regarding underlying functional forms or the human behavior undergirding those functional forms.
2. Linear regression and some other common parametric techniques such as logit and vector auto regression do make explicit assumptions about functional forms. Therefore, when these techniques are used in applications with economic variables, they often implicitly or even explicitly involve assumptions about human behavior. However, such assumptions are often merely technical and hence not very restrictive conceptually.
3. At the other extreme, techniques such as generalized method of moments or simulated method of moments are used to estimate parameters of fully developed theoretical models. Such models are often built on fairly restrictive assumptions regarding human behavior.

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As described above, econometrics can be done without developing a formal model of human behavior. However, it is important to note that econometrics is often used to build better mathematical theories of human behavior. Moreover, recent advances in empirical techniques (mostly from the second group) have led to a 'credibility revolution' in econometrics, which can be described as a significant improvement in the ability of econometricians to identify causal relationships among economic variables.[1] And better econometric analysis has enabled a deeper understanding of at least some aspects or consequences of human behavior.

Despite the success of the credibility revolution, many economists perceive its contributions to be somewhat piecemeal and non-generalizable. Two criticisms of several commonly used econometric approaches include:

1. Lucas critique: Lucas (1983) argues that empirical relationships observed in historical data cannot reliably predict consequences of policy changes. This is because when policies change, humans adapt to the new policy environment in ways that fundamentally change historically observed relationships. Therefore, reliable policy analyses require generalizable models of innate human behavior that remains invariant to the policy regime.
2. Generalizability: Another concern is the lack of generalizability of specific econometric findings. This concern typically comes in two forms.
    a. Even when a study is internally valid (i.e., the findings accurately identify relationships within the analyzed samples), it might not be externally valid (i.e., the findings from the study may not be applicable in other places and/or at other times). To be externally valid, several convincing studies across time and geography need to deliver similar results and/or those studies need to build and be built upon generalizable models of human behavior.
    b. Similarly, narrow findings from econometric studies might not capture the knock-on, feedback, and unintended consequences of a policy change. In economic parlance, findings from micro-econometric studies might not accurately reflect macroeconomic or 'general equilibrium' consequences. Macroeconomic models are required to identify macroeconomic consequences. Such models typically require assumptions regarding human behavior.

Consequently, many economists have continued to devote their energies towards building more comprehensive and formal models of the economy which require factoring in human behavior.

1.3 Approaches that make simplifying assumptions related to human behavior in order to create tractable models

To build tractable models of the economy, it is necessary to make simplifying assumptions regarding human behavior. Different economic schools of thought make different kinds of implicit or explicit assumptions regarding human behavior. While this essay focuses on the mainstream or orthodox tradition as well as criticisms of that tradition, I think it is worthwhile to briefly mention how two important heterodox schools of economic thought model human behavior:[2]

[1] Angrist and Pischke (2010) provides an excellent overview of the credibility revolution.
[2] Section 1.1 discusses the Austrian school, another important heterodox tradition.

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- Post-Keynesian economists focus on the fundamental uncertainty faced by humans when they make decisions and therefore assume that humans follow simple rules or heuristics determined by social and institutional norms, which in turn could depend on changing social, institutional, and macroeconomic circumstances. According to Lavoie (2014): "Economic agents, on this view, live in an environment either devoid of relevant information or characterized by an overload of unreliable information, and hence must follow some simple rules to make decisions without wasting too much time and resources. Agents attempt to achieve norms and will modify their short-run behavior when these norms are not satisfied, thus reacting to what they perceive as disequilibria. In the long run, norms will be modified if they are continuously under- or over-achieved, or if changes in society at large have an impact on what is considered normal in the economic field." (16)
- Institutional economists assume that human behavior and economic institutions coevolve. Humans are therefore modeled as "interactive and partially malleable agents, mutually entwined in a web of partially durable and self-reinforcing institutions." (Hodgson 1998, 175). Within this framework, "the nature of human agency [is], based on the concept of habit. Habits and rules are seen as necessary for human action." (Hodgson 1998, 167).

While these longstanding heterodox approaches are appealing to many economists, they are rejected by most mainstream economists who prefer the rational choice model of the neoclassical school instead.

2. Rational choice

Rational choice models are the most common among economic models. In this approach, people (or economic agents) are modeled as goal-directed utility maximizers and are assumed to make optimal (i.e., rational) choices. Such agents are often referred to as belonging to the fictitious species, *homo economicus*. Unlike *homo sapiens,* members of *homo economicus* always act rationally and are perfectly informed and unconstrained by limitations of memory or computing power.

Only four simple assumptions are needed for rational choice models, two of which are mathematical while the other two are conceptual and perhaps even implicit:

1. Information: Agents know their choices and the outcome associated with each choice.
2. Completeness: Agents can make pairwise comparisons across all outcomes and recognize whether they prefer one or the other outcome or are indifferent between the two.
3. Transitivity: If an agent prefers outcome 'a' to 'b' and also prefers 'b' to 'c,' she necessarily prefers outcome 'a' to outcome 'c.' Together with assumptions 1. and 2., this implies agents can consistently and reliably rank all their choices from most to least preferred.
4. Optimization: Agents choose their most preferred outcome.

When combined with the idea that a person's tacit preferences are revealed by their actual choices, preferences can be expressed as fully specified mathematical 'utility functions' that can be estimated from data on people's choices. Utility functions enable modelers to conduct mathematical analysis very conveniently (e.g., they can use calculus to find optimal decisions).

I believe rational choice models are popular because: (1) they are easy to describe in precise and tractable mathematical terms, (2) they are parsimonious in terms of underlying assumptions, and (3)

they are powerful in terms of their range of possible applications.[3] Thus, even though *homo economicus* and *homo sapiens* are markedly different, rational choice models ae especially appealing to economists who prefer fully specified mathematical models of decision-making.

2.1 Extensions of rational choice models

Rational choice models are easy to extend and have therefore been extended in several ways.

2.1.1 Uncertainty

Rational choice models are often extended to incorporate uncertainty. For example, a person might have two choices: buy a raffle ticket or keep her money. If she chooses the latter, she gets to keep her money with certainty. However, if she chooses the former there are two possible outcomes (winning the raffle or losing it), based on chance. The person needs to rationally decide whether to buy the raffle ticket before knowing whether she will win.

Expected utility theory, based on the von Neumann-Morgenstern utility theorem, allows uncertainty to be incorporated in rational choice. It requires three additional assumptions.

1. Information regarding probabilities: Agents know the likelihood (probability) of each of uncertain outcome coming to bear.
2. Continuity: If an agent prefers outcome 'a' to 'b' and prefers 'b' to 'c', then there exists some value of probability strictly between 0 and 1 such that the agent is indifferent between receiving outcome 'b' with certainty and receiving a probabilistic combination of outcomes 'a' and 'c.'
3. Independence: If outcome 'a' is preferable to outcome 'b', a probabilistic combination of outcomes 'a' and some other outcome 'c' will necessarily be preferrable to the same probabilistic combination of outcomes 'b' and 'c.'

With these additional assumptions in place, agents can once again consistently and reliably rank their preferences across all the choices available to them despite any uncertainty prevalent in them.

2.1.2 Microfounded macroeconomic models

Rational choice is a foundational assumption in several mainstream macroeconomics models. Such models are called 'microfounded' since they place *individual* human behavior (as described by rational choice) rather than institutions, aggregate relationships, norms, evolutionary processes, etc. at the center of their analyses. The standard microfounded macroeconomic model assumes:

1. Rationality: All agents are rational. Further, several models incorporate rational expectations too, i.e., an agent's understanding of the probabilities associated with each outcome matches the true probabilities of those outcomes coming to bear.
2. Complete markets: Markets exist for <u>all</u> goods and services. This assumption rules out externalities because all externalities will be internalized through market transactions. For example, if a market exists for pollutants where polluters can buy the right to pollute from those who suffer the consequences of pollution then pollution will cease to be an externality.

[3] Another reason could be historical coincidence. Preeminent economists adopted this framework when mathematical techniques were ascendant in economics and inertial forces (or path dependence) inherent to the research process have led to its continued popularity. Yet another reason could be the name 'rational' choice! Who would want to model agents as being irrational?

3. Perfect competition: All markets are perfectly competitive.

With these assumptions,[4] equilibrium outcomes will necessarily be Pareto-optimal. This result, known as the first fundamental theorem of welfare economics, is often used to justify free markets. Thus, in the standard microfounded macroeconomic model, human beings are idealized as *homo economicus*, and the economic environment is idealized as perfectly competitive complete markets. Predictably, with these idealizations, outcomes are ideal too. Two important caveats are in order:

- Several influential macroeconomic models have been built without these assumptions. Consequently, in these models, market equilibria fail to achieve Pareto-optimality.
- While it can be argued that all desirable outcomes are Pareto-optimal, few economists would suggest that all Pareto-optimal outcomes are desirable.[5]

2.1.3 Extensions beyond market interactions

Given their simplicity, parsimony, and versatility, it is unsurprising that rational choice models have been applied in several different areas that were previously considered to be outside the bounds of economics. Gary Becker, winner of the 1992 Nobel memorial prize in economics, can be credited with spearheading this movement. He successfully incorporated rational choice models to analyze crime and punishment, discrimination, division of labor within households and families, etc. As a simple unified framework, the rational choice model has influenced other social sciences including political science and even sociology. Coleman and Farraro (1992) present a detailed discussion of how rational choice theory has influenced social science more generally and sociology more specifically.

3. Some early criticisms of the rational choice model

Given its near ubiquity in economic analyses and its considerable prevalence in other social sciences, rational choice theory has long been the subject of much criticism from several different perspectives.

- Foundational concerns – Amartya Sen and Joan Robinson: Amartya Sen questions how a single preference ordering across outcomes can capture diverse facets of human behavior. According to Sen (1977, 335-336), “A person is given one preference ordering, and as and when the need arises this is supposed to reflect his interests, represent his welfare, summarize his idea of what should be done, and describe his actual choices and behavior. Can one preference ordering do all these things? A person thus described may be "rational" in the limited sense of revealing no inconsistencies in his choice behavior, but if he has no use for these distinctions between quite different concepts, he must be a bit of a fool.” Here is an example to illustrate Sen’s argument:
    - What would I *like to do?* Watch a movie.
    - What *should I be doing*? Complete my overdue grading.
    - What activity *would be best for my long-term wellbeing*? A run on the treadmill.

[4] A further technical assumption of local non-satiation is also needed.

[5] Pareto-optimality is an overall outcome such that no individual can be made better off without someone else being made worse-off. So, if an outcome is not Pareto-optimal, by definition, at least one individual can be made better off without making anyone else worse off. Based on this reasoning, all desirable final outcomes tend to be Pareto-optimal. However, not all Pareto-optimal outcomes are desirable. For example, an outcome where one agent owns everything while others have nothing is Pareto-optimal (no agent cannot be made better off without hurting the first agent) but would be considered unfair by most.

- What am I *doing*? Mindlessly 'doomscrolling' through Twitter!

Depending on the specific question being asked, my preference ordering changes, whereas my actual behavior fails to reveal any of those preferences! In Robinson (1964), Joan Robinson makes a somewhat related argument against utility functions. She argues that utility functions are circular concepts – what one does is presumed to be (by the theory of revealed preferences) the action that provides the most utility and, at the same time, what one is supposed to do is the action that provides the most utility.

- Humans do not optimize – John Maynard Keynes and Herbert Simon: Keynes argued that human beings often act in irrational ways. Keynes used the term 'animal spirits' to describe some of these irrational behaviors spurred by the 'spontaneous optimism' of human beings: "a large proportion of our positive activities depend on spontaneous optimism rather than on a mathematical expectation, whether moral or hedonistic or economic. Most of our decisions to do something positive, the full consequences of which will be drawn out over many days to come, can only be taken as a result of animal spirits – of a spontaneous urge to action rather than inaction, and not as the outcome of a weighted average of quantitative benefits multiplied by quantitative probabilities." (Keynes 1953, 161)[6] Herbert Simon also argues that humans fail to optimize. According to Simon (1956), human beings 'satisfice' (a portmanteau of satisfy and suffice) rather than optimize. When humans confront complex problems, they stop exploring further solutions as soon as they discover a choice that satisfies them sufficiently. Simon's criticism is less radical than Keynes's – the former suggests humans work out a 'good enough' solution rather than *the* best solution while the latter suggests that humans occasionally act based on impulses and emotion rather than reason. Both criticisms ultimately imply that human behavior violates rational choice.

- Agents unaware of probabilities – Frank Knight: In a seminal book Frank Knight (1921) highlighted an important distinction between two similar concepts, 'risk' and 'uncertainty.' Risk entails situations where the likelihood of each outcome coming to bear can be measured in terms of probabilities while uncertainty involves situations where those probabilities are immeasurable. Since many real-world situations involve Knightian uncertainty rather than risk, the first assumption required for rational choice with uncertainty is no longer applicable.[7]

Collectively, these criticisms suggest that even though rational choice remains a dominant approach, there is by no means unanimous agreement among economists about its relevance and applicability. In

[6] Keynes's works include several descriptions of human behavior deviating from rational choice theory. In his Nobel Memorial Prize winning lecture, George Akerlof acknowledged the influence of Keynes on his own endeavors: "[My] dream was the development of a behavioral macroeconomics in the original spirit of John Maynard Keynes' General Theory (1936). Macroeconomics would then no longer suffer from the "ad hockery" of the neoclassical synthesis, which had overridden the emphasis in The General Theory on the role of psychological and sociological factors, such as cognitive bias, reciprocity, fairness, herding, and social status. My dream was to strengthen macroeconomic theory by incorporating assumptions honed to the observation of such behavior." (Akerlof 2002, 411)

[7] Keynes also discussed situations where the probabilities associated with each outcome are not just immeasurable but also unknowable. This extreme type of uncertainty (i.e., fundamental uncertainty) occurs when the probabilities themselves get created only in the future as the economy undergoes radical and unforeseeable changes.

fact, despite and perhaps because of its dominance, the rational choice approach to essentializing human beings has been and remains contentious.

4. Responses to criticisms of the rational choice model

Economists defending rational choice make one or more of the following arguments:

- Tractability: While realism has its advantages, tractability is necessary since it allows models to be solved. Cherrier (2022) lists many prominent economists ranging from Joan Robinson in 1932 to several current-day economists who have defended their "tractability vs realism tradeoff against alternative methodologies proposed." (5) Rational choice models are often more tractable than other more realistic models of human behavior.

- As-if economics – parsimony and predictive power: A common analogy compares models to maps. For instance, a map of postal zones within a city will differ greatly from a map of subway routes in the city. While both reflect aspects of reality pertinent for their own purpose, they are parsimonious in that they simplify along all unnecessary dimensions.

  Similarly, since humans clearly respond to incentives, proponents of rational choice argue that it offers an insightful simplification without compromising on the key element of reality most pertinent to human decision-making. In a famous example, Friedman (1953) discusses a model of an expert billiard player's shot-making: "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…" (21, emphasis added) In this view, it would be similarly pertinent to model human behavior 'as if' it were in accordance with rational choice.

  Rather than using realism as a metric to evaluate models, Friedman advocates relying on the accuracy of a model's predictions. "[T]he relevant question to ask about the "assumptions" of a theory is not whether they are descriptively "realistic," for they never are, but whether they are sufficiently good approximations for the purpose in hand. And this question can be answered only by seeing whether the theory works, which means whether it yields sufficiently accurate predictions." (Friedman 1953, 15)

  Freidman further argues that since good theory is parsimonious, "Truly important and significant hypotheses will be found to have "assumptions" that are wildly inaccurate descriptive representations of reality, and, in general, the more significant the theory, the more unrealistic the assumptions (in this sense). The reason is simple. A hypothesis is important if it "explains" much by little, that is, if it abstracts the common and crucial elements from the mass of complex and detailed circumstances surrounding the phenomena to be explained and permits valid predictions on the basis of them alone."

(Friedman 1953, 14) Seen this way, the absence of realism in rational choice theory can even be considered a virtue rather than a failing!

- No generalizable alternative: The rational choice serves as a convenient and common starting point for analysis across multiple domains within economics. Within the broad field of microeconomics, consumer theory is often rooted in utility maximization while producer theory is based on profit maximization. Similarly, within game theory, agents are typically assumed to behave in accordance with the core tenet of rational choice – they act strategically to maximize their payoffs. Finally, in macroeconomics too, households and firms are typically modeled as maximizing their respective objectives through the framework of rational choice. Thus, rational choice models offer a theoretically appealing general and generalizable framework.

  Since deviations from rational choice could occur in several different ways, proponents of rational choice theory sometimes argue that any particular deviation would necessarily be 'ad hoc.' In the words of De Grauwe (2012, vii), "The proponents of the paradigm of the fully informed rational agent have told us that there are millions of different ways one can depart from rationality. There is thus no hope of coming to any meaningful conclusion once we wander into the world of irrationality. This argument has been very powerful. It has been used to discredit any attempt to depart from the paradigm of the rational and fully informed agent."

5. Two revolutions

Despite its widespread prevalence, I believe rational choice is past its heyday, primarily due to two tectonic shifts that have transformed the discipline of economics.

5.1 Behavioral economics

Human psychology has long featured in economics frameworks and can readily be traced at least as far back as Adam Smith, the father of modern economics. Describing Smith's book, 'The Theory of Moral Sentiments,' Ashraf et al. (2005) write, "Some of the discussion relates to aspects of individual preference and judgment: what we would today call loss aversion, intertemporal choice and overconfidence. Other parts of the discussion focus on preferences that arise in social contexts: altruism, fairness and how they together generate trust in markets." (132) Smith, like many subsequent economists, perceived humans to be quite unlike *homo economicus*.

Despite being long acknowledged, behavioral economics became influential in the field only in recent decades. It won this influence due to the increasing corpus of empirical evidence of humans deviating from rationality as described by the standard rational choice model. Mullainathan and Thaler (2000) discuss literature suggesting humans exhibit bounded rationality, bounded willpower (they fail to consider long-run interests) and bounded self-interest (they care about others). Similarly, humans provide inconsistent answers to the same question when the question is framed differently. According to Tversky and Kahneman (1981, 453) "The dependence of preferences on the formulation of decision problems is a significant concern for the theory of rational choice." Humans also get influenced by how they perceive their identity. Akerlof and Kranton, pioneers in this line of research, "incorporate the psychology and sociology of identity into an economic model of behavior." (Akerlof and Kranton 2000,

715) Similarly, Bowles and Gintis (2008) point out that humans care not just about outcomes but also about processes (a bad outcome is more upsetting when the process causing it is unfair) and social circumstances influence preferences too. While these and other behavioral findings can often be incorporated into the rational choice model with appropriate algebraic tweaks, such a model would be rather non-standard.

These developments in behavioral economics are leading to rational choice models being discarded in favor of more realistic models of human behavior. Although slow, this transformation in economics is occurring at all levels. Describing a new introductory economics textbook by Laibson, Acemoglu, and List[8], Rosalsky (2018) writes, "Instead of a few pages buried in the last chapter, Laibson, Acemolgu, and List scatter concepts from behavioral economics throughout the book. And they dedicate entire chapters to issues like the economics of information and the social dimensions of human behavior." At the level of sophisticated research, more and more models are deviating from standard rational choice, and when researchers do use standard rational choice, they often take pains to justify why it is applicable in the context of their research question. Like a slow but significant ongoing tectonic shift, this trend is likely to continue. Richard Thaler (2000) predicts future models will feature economic agents who are slow to learn, less rational, and more emotional.

5.2 Great recession

If behavioral economics can be likened to a slow but significant internal tectonic shift in economic modeling, perhaps the great recession of 2007-2009 could similarly be likened to a meteor strike! While it is unfair to malign the discipline for failing to forecast this recession,[9] the dearth of contemporary mainstream models that could satisfactorily explain the recession led to much self-reflection by economists. Speaking to the broader public in the pages of The New York Times, Krugman (2009) opined, "As I see it, the economics profession went astray because economists, as a group, mistook beauty, clad in impressive-looking mathematics, for truth… They turned a blind eye to the limitations of human rationality that often lead to bubbles and busts." Similarly, addressing primarily fellow economists, Ricardo Caballero (2009, 90) lamented, "We are digging ourselves, one step at a time, deeper and deeper into a Fantasyland, with economic agents who can solve richer stochastic general equilibrium problems containing all sorts of frictions. Because the 'progress' is gradual, we do not seem to notice as we accept what are increasingly absurd behavioral conventions and stretch the intelligence and information of underlying economic agents to levels that render them unrecognizable." The same basic criticism was leveled in popular press books too. For instance, Nobel Memorial Prize winning economists Akerlof and Shiller argued that "So many members of the macroeconomics and finance profession have gone so far in the direction of 'rational expectations' and 'efficient markets' that they fail to consider the most important dynamics underlying economic crises. Failing to incorporate animal spirits into the model can blind us to the real sources of trouble." (Akerlof and Shiller 2009, 167).

A common theme in much of this soul-searching literature was a harking back to older macroeconomic models where rational choice was not generally assumed. Caballero (2010) cites Knightian uncertainty while Krugman (2009) and Akerlof and Shiller (2009) refer to Keynesian animal

[8] Acemoglu, Daron, David Laibson, and John List. *Economics*. 2nd edition. New York: Pearson, 2017.

[9] I think it is unfair to malign the whole discipline for two reasons: (i) forecasting recessions is a very small fraction of what economists do, and (ii) several prominent economists did forecast the recession.

spirits. Consequently, several current strands of economic research invoke these older ideas and formalize them through behavioral frameworks that model human beings more realistically.

6. Recent developments in modeling human behavior

There have been several attempts to introduce more realistic human behavior into economic models. One important strand of the literature builds on the idea of rational inattention in which economic agents, cognizant of their limited ability optimally choose to restrict their attention as appropriate. According to the originator of this idea, Sims (2003, 666), "Most recently, theories that postulate deviations from the assumption of rational, computationally unconstrained agents have drawn attention… This paper suggests yet another direction for deviation from the seamless model, based on the idea that individual people have limited capacity for processing information."

Another important strand of the literature incorporates more realistic behavioral elements into the preference structure or utility. For instance, Rabin (1993) adds fairness, Fehr et al. (1997) adds reciprocity, Laibson (1997) adds time-inconsistent preferences, etc. These tweaked utility functions enable rational choice to persist as a general framework – economic agents maximize their utility just like *homo economicus* with the only change being the non-standard arguments that go into their utility functions. While these tweaks were introduced in the behavioral economics literature, in recent years they have made their way to the broader literature; for instance, Benjamin (2015) incorporates fairness in a model of labor markets, Danthine and Kurmann (2010) examine the role played by reciprocity on macroeconomic business cycles, and Heidhues and Kőszegi (2010) study how lenders in credit markets exploit individuals who have time inconsistent preferences for immediate gratification.

Rational choice models (and their tweaked versions[10] that incorporate rational inattention or non-standard preferences) make two related important but questionable assumptions:

1. Intrinsic human motivations and preferences are assumed to be ontologically prior to the economic circumstances being modeled
2. All analysis occurs at the level of individual humans rather than at the level of societies.[11]

Both these assumptions are being challenged more often in recent work. Some economists, taking a very long-term view, have focused on finding preferences that lead to evolutionarily stable human societies, see for instance, Possajennikov (2000), Heifetz et al. (2007), Alger and Weibull (2010), Rieger (2014), etc. An important and interesting commonality among these papers is the finding that strictly rational behavior (as described by the standard model) is typically not evolutionary stable which then directly calls into question the validity of the standard model. A related approach focuses on the co-

[10] The fact that the rational choice framework can be tweaked to incorporate all sorts of anomalies is often considered a strength. However, this flexibility makes the framework susceptible to a different kind of critique: since rational choice models can admit anything as an argument in the objective function and anything as a constraint for the maximization problem, they could be considered Panglossian, i.e., capable of explaining anything and therefore ultimately explaining nothing. Moreover, since modelers can exploit this flexibility to produce any result they desire, the framework can also be attacked as *ad hoc* based on Amable et al.'s (1997) interpretation of the term.

[11] The heterodox school of thought, ecological economics, takes it a step further and models humans as one of the many interacting parts within a complex ecosystem.

evolution of human institutions and human preferences Bowles (1998, 2010).[12] Yet another recent approach, often referred to as complexity economics,[13] involves modeling the economy as a complex adaptive system, i.e., a dynamic system that involves many interacting components with the capacity to adapt and learn. According to Arthur (2021, 136), "Complexity economics sees the economy — or the parts of it that interest us — as not necessarily in equilibrium, its decision makers (or agents) as not super-rational, the problems they face as not necessarily well-defined and the economy not as a perfectly humming machine but as an ever-changing ecology of beliefs, organizing principles and behaviors." Similarly, according to Setterfield and Gouri Suresh (2014, 809), the economy can be modeled as "a synchronically irreducible evolving system, meaning that it is subject to endogenously generated structural change involving novelty. This in turn gives rise to chronic information problems manifest in the fundamental uncertainty that confronts decision makers in the long run and that render long-run dynamic optimisation consistent with the 'true' model of the economy impossible in principle… The situation described above neither renders individual decision making entirely arbitrary nor the economy as a whole subject to continuous kaleidic revision. Instead, the economy creates and, for discrete periods or episodes of calendar time, maintains macroscopic 'operating systems' (Colander, 1999) consisting of organizational relations and institutions (rules, norms and conventions) within which individual agents operate and which lend structural stability (within any given episode) to the economy." Models within complexity economics often abandon the preference maximization framework of (boundedly) rational agents. Instead, economic agents are modeled as following heuristics or rules of thumb. While this approach has a long history[14] and is justifiable in terms of human psychology (Tversky and Kahneman, 1974), it has experienced a recent resurgence.

Some of the developments discussed above lead to analytically intractable models, i.e., models that are hard or impossible to solve algebraically. However, this is becoming less and less of a concern due to advances in modern computational techniques and increases in the computational power. While several advanced computational techniques have proliferated, one that I find especially promising is agent-based modeling (ABM) which involves computer simulations of economic models with artificial agents. By offering a powerful alternative to algebraic analysis, the simulations approach renders moot the tractability advantage of rational choice models. In fact, according to several researchers in the field, ABM offers "the right mathematics for social sciences." (Borrill and Tesfatsion, 2011). As a methodology, ABM has pervaded almost all major subfields within economics and is especially useful for models in complexity economics. Proponents of agent-based complexity economics argue that their bottom-up approach of modeling human interactions and their systemwide repercussions through simulations is more realistic than the top-down approach of analytical modeling through oversimplified equilibrium equations.

As a final note on recent developments, I think it is important to mention the tremendous increase in the number of models incorporating heterogeneity of economic agents, whether it be within the

[12] The coevolution approach is similar to the well-established approach of institutional economics which was discussed in Section 1.3 of this essay. Similarly, in the longstanding post-Keynesian approach, intrinsic human motivations are assumed to vary based on the state of the economy.
[13] Complexity economics is also often considered a heterodox school.
[14] This was often the standard approach prior to the dominance of rational choice theory. Moreover, this approach persisted even during the heyday of rational choice theory in heterodox schools such as institutional economics and post-Keynesian economics.

rational choice framework or within any of the alternatives discussed in this section. As with the other new approaches, heterogeneous agent models have also been greatly bolstered by advances in computational techniques and computational power. By increasingly modeling economic agents as heterogenous, economics researchers are acknowledging that human beings, unlike standard versions of *homo economicus*, are a diverse group in terms of preferences, resources, cognitive abilities, etc.

7. Concluding remarks

In my view, economics research is now at an exciting juncture. Many economists are adopting new ways of thinking and modeling rather than merely tweaking or improving prior models. Economists are also increasingly collaborating with experts in other disciplines even beyond the social sciences, as can be seen from all the exciting ongoing work at the intersection of psychology, evolutionary biology, neuroscience, and economics. The increased willingness to look beyond disciplinary boundaries is helping economists better understand how to model humans. However, I must also concede that progress in the field is slower than optimal; the inertia inherent in academic research is a formidable force but I believe contemporary economics research is slowly overcoming it.

I would like to conclude with a few words of advice for economists and non-economists:

- Economists: Human society and the economy at large are incredibly complex and even the most valiant of attempts to model it all is bound to be inadequate. It therefore behooves practitioners of our discipline to be humble and acknowledge our limitations. As a practical matter, I also think it is important for us economists to better incorporate recent research into introductory economics books and the public discourse.
- Non-economists: Economics is a diverse field with many different approaches and points of view. Criticisms that stereotype all economics based on outdated versions of a few schools of economic thought are therefore unfair. Economists are continuing to grapple with how to rationally model human beings, and while they have come a long way, they have further to go still. It is important to recognize the ongoing intellectual debates within the discipline as economists continue to make slow and steady progress at modeling the incredibly complex economy.

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