

Roos, Michael

**Article**

## Behavioral and complexity macroeconomics

European Journal of Economics and Economic Policies: Intervention (EJEEP)

**Provided in Cooperation with:**

Edward Elgar Publishing

*Suggested Citation:* Roos, Michael (2017) : Behavioral and complexity macroeconomics, European Journal of Economics and Economic Policies: Intervention (EJEEP), ISSN 2052-7772, Edward Elgar Publishing, Cheltenham, Vol. 14, Iss. 2, pp. 186-199, <https://doi.org/10.4337/ejeep.2017.02.03>

This Version is available at:

<https://hdl.handle.net/10419/277387>

**Standard-Nutzungsbedingungen:**

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

**Terms of use:**

*Documents in EconStor may be saved and copied for your personal and scholarly purposes.*

*You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.*

*If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.*



<https://creativecommons.org/licenses/by/4.0/>

# Behavioral and complexity macroeconomics

Michael Roos\*  
Ruhr-Universität Bochum, Germany

*This paper sketches the history of behavioral macroeconomics and presents four current approaches in the literature: the ad hoc behavioral approach, partial behavioral macroeconomic models, experimental macroeconomics, and behavioral DSGE models. Much of this literature is still patchwork, with a focus on isolated aspects but little theoretical integration. I argue that integrating behavioral features into New Keynesian DSGE models is not convincing because of fundamental problems of the DSGE approach. A better way to use research from behavioral economics for more realistic macroeconomic models is to turn to complexity economics and agent-based modeling. Complexity economics and behavioral economics are linked in a very natural way, since both emphasize the direct interaction of heterogeneous agents that are boundedly rational. Behavioral and complexity macroeconomics is a promising new approach that might make mainstream macroeconomics more realistic and relevant again.*

**Keywords:** *bounded rationality, methodology, microfoundations, representative agents*

**JEL codes:** *B41, B50, E03, C63*

## 1 INTRODUCTION

Many people inside and outside of economics are dissatisfied with the current state of macroeconomics. Disputes between different schools of thought such as Keynesians, Monetarists, and post-Keynesians have always been present in macroeconomics since its inception. By the early 2000s the New Classical and the New Keynesians had settled most of their disagreements and in the so-called New Neoclassical synthesis formed the DSGE school as a new and very dominant mainstream. The self-confidence of this mainstream reached its height just before the outbreak of the financial crisis, when Michael Woodford (2009) argued that there was a broad consensus in macroeconomics, especially about the adequate methods of research, and Olivier Blanchard (2009) assessed the state of macroeconomics as good, despite some open questions. The financial crisis suddenly laid open many weaknesses of the mainstream approach. On 16 July 2009 the magazine *The Economist* wrote: ‘Of all the economic bubbles that have been pricked, few have burst more spectacularly than the reputation of economics itself. ... There is a clear case for reinvention, especially in macroeconomics’ (p. 70).

One way to reinvent macroeconomics is to incorporate insights and to adopt methods from behavioral economics. Instead of assuming the fictional homo economicus, behavioral economists study humans as they really are, with their bounded rationality, bounded willpower, other-regarding preferences and emotionality. While behavioral economics is now a respected branch within microeconomics, most macroeconomists have

\* I would like to thank the organizers of the 20th FMM conference for inviting me to talk about behavioral and complexity economics at the conference. The paper benefited a lot from the discussion with the conference audience. I also owe thanks to Torsten Niechoj for helpful comments.

been ignoring this burgeoning field and regard it with considerable skepticism. But the global crisis has raised doubts, especially among younger researchers and students, about whether the state of macro really is good. Topics such as ‘irrational exuberance’ or ‘animal spirits,’ herding behavior, over-optimism, trust, greed, fear, and unfairness are common explanations for the crisis in the news, but the new mainstream in academic macroeconomics has little to say about these ideas. The crisis triggered some leading mainstream macroeconomists to admit that the methodology used was not as sound as previously thought. Woodford (2013: 304) concedes that the assumptions behind the rational expectations hypothesis are ‘heroic’ and proposes models of expectation formation that require slightly less rationality. However, his approach is far from the behavioral economics literature, since it does not ask what real people actually do, but still assumes that people are rational and ‘do not make obvious mistakes’ (*ibid.*).

Nevertheless, there is a literature that can be called behavioral macroeconomics and that incorporates elements from behavioral economics into macroeconomics. In this paper, I discuss the field of behavioral macroeconomics. It is not my aim to provide a comprehensive overview of this literature, since surveys and paper collections can be found elsewhere (for example, Camerer et al. 2003; Duffy 2008; Foote et al. 2009; McDonald 2012; Driscoll/Holden 2014; Favaretto/Masciandaro 2015; Duffy 2016). Rather, I want to sketch the main developments and provide some critique of these approaches. While I strongly support the efforts to introduce behavioral insights into macroeconomics, I see problems with the way in which this is done. My main argument is that behavioral macroeconomics should not be based on the representative-agent assumption. The representative agent in macroeconomics is a questionable construct anyway and endowing representative agents with behavioral features is not necessarily an improvement over standard mainstream models.

As an alternative I propose to combine behavioral economics with complexity economics. A very important insight of complexity economics is that researchers should carefully distinguish different levels of economic activity. In general, the dynamics of aggregate variables at the macroeconomic level are not identical to the dynamics of the individual counterparts at the microeconomic level. The same is true for welfare and optimality statements: behavior that is optimal from an individual perspective need not be socially optimal. A main reason for existence of different phenomena at the micro and the macro level is the interaction of individual agents which is ignored in representative-agent models. With conventional mathematical modeling approaches, the direct interaction of agents can be analysed to a very limited extent under highly restrictive assumptions, but new computational approaches such as agent-based computational modeling make it easy to model all kinds of behavioral features and interactions between agents. Importantly, many topics that are central in behavioral economics such as other-regarding preferences and the impact of emotions on behavior are strongly linked to the direct interaction between agents. Another shared theme of complexity and behavioral economics is that they reject the formal rationality concept of rational choice theory and prefer different concepts such as ecological or procedural rationality. Thus, behavioral economics and complexity economics are natural complements.

## 2 MICROFOUNDATIONS OF MACROECONOMICS

Mainstream macroeconomists insist that macroeconomic models need ‘rigorous microfoundations’ and reject all other approaches that do not meet this criterion. Many macroeconomists believe that aggregate models without microfoundations are at best useful

policy models but not really scientific and should not be published in leading journals (see Wren-Lewis 2007 and 2011 for a discussion of this position). For mainstream macroeconomists, ‘having microfoundations’ means that all aggregate relationships are explicitly derived from decisions of individuals so that macroeconomic models are fully consistent with neoclassical microeconomic theory. Microfoundations in this purist sense (Wren-Lewis 2007; 2011) are only internally consistent if they start with well-specified optimization problems of the agents that include the objective functions, the relevant constraints, the informational assumptions, and the choice variables. The microfoundations requirement raises the obvious question about how the macro level and the micro level of an economy are linked. In other words, how are individual decisions aggregated into macroeconomic outcomes? Mainstream macroeconomics generally solves the aggregation problem by assuming that there are representative agents. A representative household or firm stands for all households or all firms in the economy. By solving the optimization problem of the individual representative agents, the problem is also solved for all agents of this type at the same time. This means that aggregate outcomes are identical to individual outcomes (up to a scaling factor) and no particular aggregation is needed. This is of course a modeling trick to deal with the complexities of the aggregation process. The representative agent assumption is equivalent to the assumption that all agents are identical. The use of microfoundations with representative agents implies that there is no difference between the micro and the macro level. In the view of the proponents, this unification of macroeconomics and (neoclassical) microeconomics is desirable, since it allows us to study all economic phenomena within the same methodological framework. For them, the separation of macroeconomics from microeconomics before the ‘microfoundations revolution’<sup>1</sup> was unnatural (see Lucas 1987; Prescott 2006).

Non-mainstream macroeconomists, on the other hand, either do not see a need for microfoundations or argue that even if they are not explicit in a formal macroeconomic model they are implicitly there because the researcher typically has an idea how the postulated relationships between macroeconomic variables are related to the micro level. Sawyer (2010) argues that heterodox economists of course reflect on how aggregate relationships are linked to behavior at the individual level, but they do not believe that a formal aggregation to well-defined macroeconomic functions is possible. Therefore, a more precise distinction is whether the microfoundations of the macroeconomic models are explicit or implicit.

### 3 BEHAVIORAL MACROECONOMICS

Behavioral macroeconomists incorporate insights from behavioral economics about actual behavior of humans into macroeconomic models. In his Nobel lecture George Akerlof argued that important macroeconomic phenomena such as the existence of involuntary unemployment, the impact of monetary policy on output or the prevalence of undersaving for retirement cannot be understood unless behavioral considerations such as fairness, identity, money illusion, loss aversion, and procrastination are taken into account (Akerlof 2002). Behavioral economics analyses decision-making, reasoning, and the motivations of individuals and is hence a microeconomic approach by nature. If we want to apply methods and findings from behavioral economics to macroeconomic topics, the issue of microfoundations and the aggregation problem automatically arises. For this reason, models with explicit microfoundations lend themselves naturally for the transfer from behavioral

1. Often also called the ‘rational expectations revolution.’

economics to macroeconomics. This does not mean that models with microfoundations are always superior to purely aggregate models, because models without microfoundations have the benefit of making system dynamics more transparent and comprehensible. Bottom-up models that combine micro behavior with macro dynamics quickly become difficult to understand. However, if it is the aim to include insights from psychology and behavioral economics into macroeconomics, it is desirable to include individual agents explicitly, since they are the objects of behavioral economics.

### 3.1 History

While a behavioral turn in macroeconomics appears novel, it is in fact only a return to what macroeconomics had been for a long time. Macroeconomics started as a behavioral discipline and included behavioral elements for more than half of its history. Fisher (1928) and Pigou (1929) explained macroeconomic phenomena psychologically. Fisher described and analysed the effects of money illusion and Pigou saw shifts in profit expectations as a driving factor of business cycles, since they influenced investment. In his theory, expectations are driven by waves of optimism and pessimism and expectation errors.

The idea that expectations might be an exogenous factor that influences macroeconomic conditions can also be found in *The General Theory* of John Maynard Keynes (1936). Keynes was a behavioral economist in that he resorted to psychological explanations:

Thus we can sometimes regard our ultimate independent variables as consisting of (1) the three fundamental psychological factors, namely, the psychological propensity to consume, the psychological attitude to liquidity and the psychological expectations of future yield from capital-assets, (2) the wage-unit as determined by the bargains reached between employers and employed, and (3) the quantity of money as determined by the action of the central bank; so that, if we take as given the factors specified above, these variables determine the national income (or dividend) and the quantity of employment. (Keynes 1936: 247)

Keynes devotes whole chapters to each of the three psychological factors. The most famous is probably chapter 12 of *The General Theory*, which is devoted to the role of long-term expectations of investment. According to Keynes, expectations consist of forecasts and confidence, with which the forecast is made, and confidence is the subjective likelihood that the best forecast turns wrong. He discusses conventions and mass psychology as factors of confidence and argues that in many situations, confidence must be very low, because little can be known about the future. In these situations, there is no rational basis to make forecasts. In this context, he introduces his concept of animal spirits, which he defines as ‘a spontaneous urge to action rather than inaction’ (ibid.: 161), and which complements rational decision-making ‘as the outcome of a weighted average of quantitative benefits multiplied by quantitative probabilities’ (ibid.). Like current behavioral economists, Keynes had a complex picture of humans as economic actors and was ready to explain certain behavior as the result of psychological factors that are different from rational cost–benefit analysis. Keynesian macroeconomics until the 1970s often referred to psychological explanations of macroeconomic phenomena. Before the rational expectations revolution, money illusion, downward rigidities of prices, and wages due to fairness or expectation errors were common in macroeconomics.

Another important behavioral macroeconomist was George Katona (see Katona 1951; 1975). Katona received his doctorate in experimental psychology, but devoted most of his

academic life to the study of macroeconomic issues such as inflation, aggregate consumer spending and saving, and the formation of expectations. In contrast to Keynes, who was an armchair theorist, Katona's work was mainly empirical and culminated in the establishment of consumer and business confidence (or sentiment) indexes first in the US and now in many other countries. Katona was the first to perform repeated representative surveys among consumers and firms on their economic expectations and attitudes and thus made aggregate economic expectations measurable. Despite his merits for the empirical research on macroeconomic expectations, Katona is not widely known among macroeconomists. This neglect by macroeconomists can be explained by the way Katona processed his empirical findings theoretically. He did not want to develop an abstract economic theory about aggregate consumer behavior in the way it is typically done by traditional economists. Katona, rather, tried to formulate a new low-level theory that organized his empirical observations with the aid of some concepts that are well established in psychology (see Wårneryd 1982). He also stressed that consumers most of the time do not make genuine decisions, but, rather, follow habits, and that subjective factors or intervening variables are crucial for predictions of economic behavior. Katona never claimed that he had developed a complete theory of consumer behavior similar to economic theories, but what he did achieve is some kind of macro-psychological theory of consumer behavior which is not easily compatible with traditional economic models.

The rational expectations revolution in the 1970s was a dramatic change in macroeconomic thinking and eradicated all behavioral aspects from macroeconomics by assuming perfectly rational agents. In this Nobel speech, James Tobin reflected on whether unemployment should be considered voluntary and optimal and characterizes the mainstream's rejection of Keynes's ideas as follows: 'An economic theorist can, of course, commit no greater crime than to assume money illusion' (Tobin 1972: 3). Ironically, the time at which macroeconomists started to move away from psychological explanations is also the time when some seminal papers in behavioral microeconomics were published, for example Simon (1972; 1978), Tversky/Kahneman (1973; 1974) and Kahneman/Tversky (1979). Some of the older behavioral thinking in macroeconomics survived and flourished in niches. Behavioral economists worked on topics highly relevant for macroeconomics, such as saving and intertemporal decision-making, the formation of expectations, money illusion, and others. But these developments were largely unnoticed by most mainstream macroeconomists.

Behavioral ideas in and for macroeconomics received new public attention through George Akerlof's Nobel lecture, 'Behavioral macroeconomics and macroeconomic behavior,' in 2001. Since then a considerable number of papers in behavioral macroeconomics have been published (see next section). Another landmark event was the conference, 'Implications of behavioral economics for economic policy,' at the Federal Reserve Bank of Boston in 2007 (see Foote et al. 2009), which had a strong focus on monetary theory and policy. In 2012, Paul De Grauwe published the book, *Lectures on Behavioral Macroeconomics*, which can be seen as a first attempt popularize models in behavioral macroeconomics that are an alternative to the conventional mainstream.

### 3.2 Current approaches

It is fair to say that the field of behavioral macroeconomics does not offer a coherent theory or framework yet. To date it is, rather a collection of ideas and attempts to show how macroeconomic phenomena could be explained more realistically. I argue that four different approaches exist that could be labeled as behavioral macroeconomics.

### 3.2.1 *Ad hoc behavioral approach*

Mainstream macroeconomists might argue that their models have been containing a couple of behavioral features for quite some time. Many papers (for example, Krusell/Smith 1996; Weber 2002; Amato/Laubach 2003; Galí et al. 2004) assume that some consumers do not optimize intertemporally, but rather are myopic and use rules of thumb. Other papers (Mansoorian 1996; Carroll et al. 2000; Fuhrer 2000; Lettau/Uhlig 2000) model habit-formation of consumers such that utility does not only depend on current consumption but also on past consumption. Both myopia and habit formation are deviations from the standard discounted utility model that add some realism. However, the researchers' motivation to introduce these features into their models stems from empirical puzzles in the aggregate data they would like to solve. Campbell/Mankiw (1989) found empirically that standard Euler equations from intertemporal utility maximization problems do not describe the dynamics of aggregate consumption well and show that a better fit can be achieved by the assumption that a fraction of consumers is myopic. Carroll et al. (2000) want to solve the puzzle that high growth leads to high savings and not vice versa as predicted by standard neoclassical growth models. I call these modifications an *ad hoc* approach because the authors do not really care about the actual behavior of individuals and do not make any reference to the literature in behavioral economics or psychology. Galí et al. (2004) even state that the assumption of rule-of-thumb consumers is simplistic and justified only on tractability grounds.

Thomas Sargent's concept of bounded rationality in expectation formation (Sargent 1993) and the 'sticky information' models of Gregory Mankiw and Ricardo Reis (Mankiw/Reis 2002; Reis 2006a; 2006b) apparently constitute contributions to behavioral macroeconomics as well. These papers acknowledge that humans have cognitive limitations and hence cannot possess the full information needed to form rational expectations. However, the way in which this 'bounded rationality' is modeled clearly differs from the concepts of Herbert Simon and other behavior economists. Sargent (1993) proposes to model agents as economists who learn by building models, testing them empirically, and revising them when new evidence is available. It is explicitly not his aim to get 'psychologically deeper or "more realistic" models of the way people behave' (ibid.: 24). Reis (2006a; 2006b) assumes that producers and consumers are rationally inattentive, that is, they optimize over the acquisition of information needed for optimal decision-making. Rational learning and rational information acquisition add additional layers of complexity to decision problems that are already complicated. Assuming that decision-makers are able to solve these information problems in addition to the decision problems is in strong contrast to how behavioral economists model behavior.

### 3.2.2 *Partial behavioral macroeconomic models*

Behavioral economists worked on topics quite early on that are relevant for macroeconomics, but without receiving much attention from macroeconomists.

One of the earliest topics in experimental and behavioral economics was fairness, as reflected for example in the famous paper by Güth et al. (1982) on the ultimatum game. Kahneman et al. (1986) argue that fairness considerations are a constraint on the profit-seeking of firms and hence affect price-setting and wage-setting. Rotemberg (1982a; 1982b) applies the idea that customers might perceive price changes as unfair to macroeconomic price rigidity and the aggregate supply function. Akerlof (1982) and Akerlof/Yellen (1988) relate wage setting and unemployment to fairness considerations.

Richard Thaler (1980) studied how actual consumers make decisions and found that consumption decisions often contradict standard microeconomic consumer theory.

Building on the prospect theory of Kahneman and Tversky he developed the theory of mental accounting according to which people assign financial transactions to mental accounts and treat them differently, depending on the mental account. In particular, they treat financial assets on the different accounts as non-fungible which violates standard microeconomic theory. In Shefrin/Thaler (1988) the mental accounting model is applied to the life-cycle theory of saving resulting in the behavioral life-cycle theory.

Psychologists and behavioral economists found that intertemporal choices often imply time-inconsistent discounting (see Thaler 1981; Frederick et al. 2002) and are better described by hyperbolic discounting than by the standard exponential discounting. Laibson (1997) proposed to approximate hyperbolic discounting by a quasi-hyperbolic discount function and applied it to macroeconomic issues such as the high correlation between consumption and current income and the decline in US savings rates.

These papers are clearly relevant for macroeconomics and are often mentioned in the context of behavioral macroeconomics. But one might argue that they belong, rather, to behavioral economics than to macroeconomics, since they focus more on some partial aspects of economy than on the whole macroeconomic system.

### 3.2.3 *Experimental macroeconomics*

There is now a lot of research in experimental economics that is linked to macroeconomics. Duffy (2008) argues that within experimental economics the subfield of experimental macroeconomics has evolved, because analysing macroeconomic topics in the experimental laboratory involves a number of methodological challenges such as the implementation of discounting or infinite time horizons. A comprehensive survey of this literature can be found in Duffy (2016). I briefly mention some papers in the literature in order to characterize what this strand of research does.

In Duffy/Ochs (1999; 2002) the Kiyotaki–Wright search model of money is implemented in an experimental setting. The experiment is a test on whether the experimental subjects behave as predicted by the model and use an intrinsically worthless object as a medium of exchange (or money). Other experiments on monetary theory are discussed in Duffy (1998). Related research are the experiments in Fehr/Tyran (2001; 2007) on money illusion, Luhan/Scharler (2014) on inflation illusion, and Orland/Roos (2013) and Noussair et al. (2015) on aggregate price-setting.

Another important topic in experimental macroeconomics is the formation of expectations. Surveys of this literature can be found in Hommes (2011) and in Assenza et al. (2014). While some papers (for example, Sonnemans et al. 2004; Roos/Schmidt 2012; Goecke et al. 2013) analyse the formation of expectations in a partial market setting, others (for example, Roos/Luhan 2013) study how expectations are formed in a macroeconomic setting. Some of the papers that implement explicit macroeconomic models in the lab rely on the New Keynesian DGSE framework (Bao et al. 2013; Pfařfar/Žakelj 2014).

There is also a literature that tests models of intertemporal consumption and saving in the lab (for example, Hey/Dardanoni 1988; Carbone 2006; Luhan et al. 2014). Typically, these experiments test a version of the standard discounted utility model which describes consumer behavior in mainstream macroeconomic models. Often, the empirically found deficiencies of this model are corroborated in the experiments.

While all these papers are very different in detail, most of them have in common that they are rarely exploratory and do not aim at developing new theory. Instead, the majority of research in experimental macroeconomics tests existing models. Since laboratory experiments focus on the behavior of individual subjects, they typically test the microfoundations



of the macroeconomic models rather than the aggregate system behavior. This issue raises the question of the external validity of the experiments and whether this strand of research really belongs to macroeconomics or rather to microeconomics.

#### 3.2.4 Behavioral DSGE models

The literature that comes closest to the idea of behavioral macroeconomic theory combines findings from experiments and papers in behavioral economics with New Keynesian dynamic stochastic general equilibrium (DSGE) models.

Danthine/Kurmann (2004; 2007; 2010) introduce reciprocity considerations in labor relations into a DSGE model and analyse how this modification affects the business cycle dynamics. They also estimate their model empirically and compare its behavior with the properties of vector autoregressive (VAR) models. Menz (2008) modifies the forward-looking IS curve of the canonical New Keynesian model by assuming hyperbolic discounting. De Grauwe (2012) and Hommes/Lustenhouwer (2016) use non-rational expectations in New Keynesian DSGE models and apply these models to the analysis of monetary policy.

These papers have in common that they start from a New Keynesian model and alter individual aspects while they maintain the overall New Keynesian framework and its general logic. Hence the behavioral DSGE models are not consistently 'behavioral,' but, rather, have some selected behavioral features. I argue that these DGSE models with behavioral features are not very convincing for at least two reasons.

The first reason is that they rely on the representative-agent assumption. As discussed in Kirman (1992), Hartley (1997), and Delli Gatti et al. (2010), the representative-agent assumption is highly problematic and should not be used to aggregate microeconomic behavior into macroeconomic dynamics. The only valid interpretation of the representative agent is that is a collection of identical agents, not an average of heterogeneous agents. If agents are heterogeneous, the representative agent is not robust against redistribution and it is not guaranteed that a unique and stable general equilibrium exists (see Kirman 1992; Hartley 1997). Furthermore, by assuming that the micro level and the macro level are identical, one commits a fallacy of composition (see Delli Gatti et al. 2010; Lavoie 2014). If there is direct interaction between individual agents, it may not be possible to infer aggregate outcomes directly from the analysis of individuals. Different levels of a system may have different properties. A simple example is that distributions only exist at some collective level, but not at the level of individuals. To conclude that individual optimality implies collective optimality is a particularly relevant fallacy of composition in mainstream macroeconomics, which is illustrated in a simple way by the prisoners' dilemma. Status competition among households is an example of a macroeconomically relevant prisoners' dilemma: for each household it may be rational to offer more labor and to consume more than others in order to improve social status, but collectively not everyone can win this rat race which implies that aggregate labor supply and aggregate consumption are too high.

Apart from these general arguments against macroeconomic models with representative agents, there is a second reason why behavioral macroeconomic models with representative agents are not plausible: they are not consistent and typically just assume one behavioral modification while otherwise maintaining the standard framework. By 'not consistent' I mean that they mix the usual neoclassical assumptions with some behavioral features in a way that is not justified by a theory of behavior or empirical observation, but merely by mathematical convenience. As is often argued by proponents of rational expectations, it is inconsistent to assume perfectly optimizing agents that form expectations

which lead to systematic errors. However, in contrast to the defenders of rational expectations, I would propose to fit behavior to expectations and relax the strong rationality behind the optimization behavior.

A major problem is to identify the ‘right’ degree of deviation from rationality in the wilderness of bounded rationality. The most plausible way to solve the problem is to look at empirical evidence, but economic experiments typically show that subjects are heterogeneous with respect to behavior and their degree of rationality. Arbitrarily choosing one observed behavior and declaring it as representative for all agents is not convincing.

#### 4 COMPLEXITY AND BEHAVIORAL MACROECONOMICS

According to W. Brian Arthur (2015), complexity economics is a different way of thinking about the economy. In contrast to neoclassical economics, ‘it sees the economy not as a system in equilibrium but as one in motion, perpetually “computing” itself – perpetually constructing itself anew. Where equilibrium economics emphasizes order, determinacy, deduction, and stasis, this new framework emphasizes contingency, indeterminacy, sense-making, and openness to change’ (ibid.: 24). In their well-known summary, Arthur et al. (1997: 3–4) describe complexity economics by six characteristics: (i) dispersed interaction among heterogeneous agents, (ii) no global controller of the economy, (iii) cross-cutting hierarchies with tangled interactions, (iv) continual adaptation and learning by evolving agents, (v) perpetual novelty, and (vi) out-of-equilibrium dynamics with no presumption of optimality.

Complexity economics is strongly linked to some parts of behavioral economics (see Holt et al. 2011). Herbert Simon, who introduced the concept of bounded rationality, also studied complex systems and argued that in complex environments, procedural rationality is a more appropriate concept than substantive rationality (Simon 1978). Environments characterized by constant change and fundamental uncertainty make optimization impossible, because agents cannot possess the necessary information to describe decision problems in a complete way. Simon (1987) describes the role of intuition and emotion as a complement to logical decision-making in management, which resembles Keynes’s (1936) idea of animal spirits.

An aspect that naturally links behavioral economics and complexity economics is the concern for fairness. Bounded selfishness and other-regarding preferences are a major pillar of research in experimental and behavioral economics, in addition to bounded rationality and bounded will-power (see Mullainathan/Thaler 2000). Modeling fairness concerns involves two complications for conventional approaches. First, fairness issues always involve direct interaction between at least two agents. Second, the agents may have different opinions of what is fair and these opinions may also be context-specific and hence subject to change. The complexity approach, however, rests on the assumption of interacting and evolving heterogeneous agents.

Since complexity economics and behavioral economics are so closely linked, it seems natural to build behavioral macroeconomics on the foundations of complexity economics (see Delli Gatti et al. 2010). Delli Gatti et al. (2011) call this approach ‘bottom-up adaptive macroeconomics’ (p. 22) or ‘emergent macroeconomics’ (p. vii). Using the tool of agent-based simulation models, one can model the behavior of individual heterogeneous agents in terms of simple, observation-based rules and the local interaction of those agents. Both the behavioral rules and the interaction modes can be allowed to change over time based on the observed learning behavior of real agents. These models thus have

microfoundations, yet they are not axiomatic, but based on real behavior. From these microfoundations, the economy is grown in a computer simulation. This means that the model is not solved using imposed equilibrium assumptions, but computed in an algorithmic way. It may happen that stable macroeconomic patterns or equilibria occur, but they are an emergent result of the model rather than an assumption. Since the aggregation is done by computation, there is no need for dubious simplifying assumptions.

Recently, more and more papers on agent-based macroeconomic models inspired by complexity economics have been published, for example Dawid et al. (2012), Dosi et al. (2013), Assenza et al. (2015), Caiani et al. (2016), and Fagiolo/Roventini (2017). The boom of this literature demonstrates that complexity and behavioral macroeconomics is viable and a promising alternative to the less convincing attempts to combine behavioral approaches with New Keynesian DSGE macroeconomics.

## 5 CONCLUSIONS

Macroeconomics had many behavioral features right from its inception, but those were eliminated from mainstream macroeconomic thinking during the rational expectations/microfoundations revolution in the 1970s. A revival of behavioral macroeconomics began in the early 2000s and lasts until today. In this paper, I sketched the current state of behavioral macroeconomics. Much of this literature is still patchwork, with a focus on isolated aspects, but little theoretical integration. There are some first attempts to combine behavioral economics with the mainstream DSGE approach in order to build true behavioral macroeconomic models, yet they are not very convincing because of fundamental problems of the DSGE approach. With regard to the introduction of financial frictions into DSGE models after the financial crisis, Fagiolo/Roventini (2017: para. 4.9) speak of ‘patches added to torn clothes,’ which could also be said of behavioral features built into DSGE models.

A better way to use research from behavioral economics for more realistic macroeconomic models is to turn to complexity economics and agent-based modeling. This completely different perspective on the economy is still in its infancy, but has already a booming literature. Complexity economics and behavioral economics are linked in a very natural way, since both emphasize the direct interaction of heterogeneous agents that are boundedly rational.

Behavioral and complexity macroeconomics is a new way to model macroeconomic systems. It should be seen as a modeling framework instead of a macroeconomic school of thought, because it is compatible with many different macroeconomic theories. Heise (2016) sees complexity economics on both sides of the so-called orthodoxy–heterodoxy divide. This position between academic frontlines might help build bridges over deep chasms and initiate dialogue between researchers that currently have little in common. Researchers trained in neoclassical economics may find it hard not to start economic analyses at the behavior of individuals and heterodox economists vehemently reject representative agents, trivial aggregation, and strongly unrealistic assumptions. Complexity and behavioral macroeconomics may be a way to meet the needs of both parties. Furthermore, one could hope that mainstream macroeconomists will accept that issues such as income and wealth distribution, power, class conflict, systemic instability, and coordination failure are important for macroeconomics, once they are provided with a new modeling method. Heterodox economists always emphasized these topics, but their modeling approach did not convince the orthodox camp. A new method could make a fresh start possible and bring important topics from heterodox niches back onto the mainstream research agenda.

## REFERENCES

- Akerlof, G.A. (1982): Labor contracts as partial gift exchange, in: *Quarterly Journal of Economics* 97(4), 543–569.
- Akerlof, G.A. (2002): Behavioral macroeconomics and macroeconomic behavior, in: *American Economic Review*, 92(3), 411–433.
- Akerlof, G.A., Yellen, J.L. (1988): Fairness and unemployment, in: *American Economic Review*, 78(2), 44–49.
- Amato, J.D., Laubach, T. (2003): Rule-of-thumb behaviour and monetary policy, in: *European Economic Review*, 47(5), 791–831.
- Arthur, W.B. (2015): *Complexity and the Economy*, Oxford: Oxford University Press.
- Arthur, W.B., Durlauf, S.N., Lane, D.A. (eds) (1997): Introduction, in: *The Economy as an Evolving Complex System II*, Redwood City, CA: Addison-Wesley, 1–14.
- Assenza, T., Bao, T., Hommes, C., Massaro, D. (2014): Experiments on expectations in macroeconomics and finance, in: Duffy, J. (ed.), *Experiments in Macroeconomics*, Bingley, UK: Emerald Group Publishing, 11–70.
- Assenza, T., Delli Gatti, D., Grazzini, J. (2015): Emergent dynamics of a macroeconomic agent based model with capital and credit, in: *Journal of Economic Dynamics and Control*, 50, 5–28.
- Bao, T., Duffy, J., Hommes, C. (2013): Learning, forecasting and optimizing: an experimental study, in: *European Economic Review*, 61(C), 186–204.
- Blanchard, O. (2009): The state of macro, in: *Annual Review of Economics*, 1(1), 209–228.
- Caiani, A., Godin, A., Caverzasi, E., Gallegati, M., Kinsella, S., Stiglitz, J.E. (2016): Agent based–stock flow consistent macroeconomics: towards a benchmark model, in: *Journal of Economic Dynamics and Control*, 69, 375–408.
- Camerer, C.F., Loewenstein, G., Rabin, M. (eds) (2003): *Advances in Behavioral Economics*, Princeton, NJ: Princeton University Press.
- Campbell, J.Y., Mankiw, N.G. (1989): International evidence on the persistence of economic fluctuations, in: *Journal of Monetary Economics*, 23(2), 319–333.
- Carbone, E. (2006): Understanding intertemporal choices, in: *Applied Economics*, 38(8), 889–898.
- Carroll, C.D., Overland, J., Weil, D.N. (2000): Saving and growth with habit formation, in: *American Economic Review*, 90(3), 341–355.
- Danthine, J.P., Kurmann, A. (2004): Fair wages in a New Keynesian model of the business cycle, in: *Review of Economic Dynamics*, 7(1), 107–142.
- Danthine, J.P., Kurmann, A. (2007): The macroeconomic consequences of reciprocity in labor relations, in: *Scandinavian Journal of Economics*, 109(4), 857–881.
- Danthine, J.P., Kurmann, A. (2010): The business cycle implications of reciprocity in labor relations, in: *Journal of Monetary Economics*, 57(7), 837–850.
- Dawid, H., Gemkow, S., Harting, P., van der Hoog, S., Neugart, M. (2012): The Eurace@Unibi model: an agent-based macroeconomic model for economic policy analysis, Tech. Rep. 05-2012, Bielefeld Working Papers in Economics and Management.
- De Grauwe, P. (2012): *Lectures on Behavioral Macroeconomics*, Princeton, NJ: Princeton University Press.
- Delli Gatti, D., Gaffeo, E., Gallegati, M. (2010): Complex agent-based macroeconomics: a manifesto for a new paradigm, in: *Journal of Economic Interaction and Coordination*, 5(2), 111–135.
- Delli Gatti, D., Desiderio, S., Gaffeo, E., Cirillo, P., Gallegati, M. (2011): *Macroeconomics from the Bottom Up*, Milan: Springer.
- Dosi, G., Fagiolo, G., Napoletano, M., Roventini, A. (2013): Income distribution, credit and fiscal policies in an agent-based Keynesian model, in: *Journal of Economic Dynamics and Control*, 37, 1598–1625.
- Driscoll, J.C., Holden, S. (2014): Behavioral economics and macroeconomic models, in: *Journal of Macroeconomics*, 41, 133–147.
- Duffy, J. (1998): Monetary theory in the laboratory, *Federal Reserve Bank of St. Louis Review*, 80(September/October), 9–26.
- Duffy, J. (2008): Experimental macroeconomics, in: Durlauf, S.N., Blume, L.E. (eds): *The New Palgrave Dictionary of Economics*, 2nd edn, New York: Palgrave Macmillan, online.

- Duffy, J. (2016): Macroeconomics: a survey of laboratory research, in: Kagel, J.H., Roth, A.E. (eds), *The Handbook of Experimental Economics Vol. 2*, Princeton, NJ: Princeton University Press, 1–90.
- Duffy, J., Ochs, J. (1999): Emergence of money as a medium of exchange: an experimental study, in: *American Economic Review*, 89(4), 847–877.
- Duffy, J., Ochs, J. (2002): Intrinsically worthless objects as media of exchange: experimental evidence, in: *International Economic Review*, 43(3), 637–673.
- Economist, The* (2009): What went wrong with economics – and how the discipline should change to avoid the mistakes of the past, 16 July, URL: <http://www.economist.com/node/14031376>.
- Fagiolo, G., Roventini, A. (2017): Macroeconomic policy in DSGE and agent-based models redux: new developments and challenges ahead, in: *Journal of Artificial Societies and Social Simulation*, 20(1), URL: <http://jasss.soc.surrey.ac.uk/20/1/1.html>.
- Favaretto, F., Masciandaro, D. (2015): Behavioral economics and monetary policy, BAFI CARE-FIN Centre Research Paper No 2015-1.
- Fehr, E., Tyran, J.-R. (2001): Does money illusion matter?, in: *American Economic Review*, 91(5), 1239–1262.
- Fehr, E., Tyran, J.-R. (2007): Money illusion and coordination failure, in: *Games and Economic Behavior*, 58(2), 246–268.
- Fisher, I. (1928): *The Money Illusion*, New York: Adelphi.
- Foote, C.L., Goette, L., Meier, S. (eds) (2009): *Policymaking Insights from Behavioral Economics*, Boston: Federal Reserve Bank of Boston.
- Frederick, S., Loewenstein, G., O'Donoghue, T. (2002): Time discounting and time preference: a critical review, in: *Journal of Economic Literature*, 40(2), 351–401.
- Fuhrer, J.C. (2000): Habit formation in consumption and its implications for monetary-policy models, in: *American Economic Review*, 90(3), 367–390.
- Galí, J., López-Salido, J.D., Vallés, J. (2004): Rule-of-thumb consumers and the design of interest rate rules, in: *Journal of Money, Credit and Banking*, 36(4), 739–763.
- Goecke, H., Luhan, W.J., Roos, M.W.M. (2013): Rational inattentiveness in a forecasting experiment, in: *Journal of Economic Behavior and Organization*, 94, 80–89.
- Güth, W., Schmittberger, R., Schwarze, B. (1982): An experimental analysis of ultimatum bargaining, in: *Journal of Economic Behavior and Organization*, 3(4), 367–388.
- Hartley, J.E. (1997): *The Representative Agent in Macroeconomics*, London and New York: Routledge.
- Heise, A. (2016): Whither economic complexity? A new heterodox paradigm or just another variation within the mainstream?, ZÖSS Discussion papers DP 58.
- Hey, J.D., Dardanoni, V. (1988): Optimal consumption under uncertainty: an experimental investigation, in: *Economic Journal*, 98(390), 105–116.
- Holt, R.P.F., Barkley Rosser Jr, J., Colander, D. (2011): The complexity era in economics, in: *Review of Political Economy*, 23(3), 357–369.
- Hommes, C. (2011): The heterogeneous expectations hypothesis: some evidence from the lab, in: *Journal of Economic Dynamics and Control*, 35(1), 1–24.
- Hommes, C.H., Lustenhouwer, J. (2016): Managing heterogeneous and unanchored expectations: a monetary policy analysis, CeNDEF Working Papers 16-01.
- Kahneman, D., Tversky, A. (1979): Prospect theory: an analysis of decisions under risk, in: *Econometrica*, 47(2), 263–291.
- Kahneman, D., Knetsch, J.L., Thaler, R. (1986): Fairness as a constraint on profit seeking: entitlements in the market, in: *American Economic Review*, 76(4), 728–741 .
- Katona, G. (1951): *Psychological analysis of economic behavior*, New York: McGraw-Hill.
- Katona, G. (1975): *Psychological Economics*, New York: Elsevier.
- Keynes, J.M. (1936): *The General Theory of Employment, Interest and Money*, London: Macmillan.
- Kirman, A.P. (1992): Whom or what does the representative individual represent?, in: *Journal of Economic Perspectives*, 6(2), 117–136.
- Krusell, P., Smith, A.A. (1996): Rules of thumb in macroeconomic equilibrium: a quantitative analysis, in: *Journal of Economic Dynamics and Control*, 20(4), 527–558.
- Laibson, D. (1997): Golden eggs and hyperbolic discounting, in: *Quarterly Journal of Economics*, 112(2), 443–478.

- Lavoie, M. (2014): *Post-Keynesian Economics: New Foundations*, Cheltenham, UK and Northampton, MA: Edward Elgar.
- Lettau, M., Uhlig, H. (2000): Can habit formation be reconciled with business cycle facts?, in: *Review of Economic Dynamics*, 3(1), 79–99.
- Lucas, R.E. (1987): *Models of Business Cycles*, Oxford: Basil Blackwell.
- Luhan, W.J., Scharler, J. (2014): Inflation illusion and the Taylor principle: an experimental study, in: *Journal of Economic Dynamics and Control*, 45, 94–110.
- Luhan, W.J., Roos, M.W.M., Scharler, J. (2014): An experiment on consumption responses to future prices and interest rates, in: Duffy, J. (ed.), *Experiments in Macroeconomics*, Bingley, UK: Emerald Group Publishing, 139–166.
- Mankiw, N.G., Reis, R. (2002): Sticky information versus sticky prices: a proposal to replace the New Keynesian Phillips curve, in: *Quarterly Journal of Economics*, 117(4), 1295–1328.
- Mansoorian, A. (1996): On the macroeconomic policy implications of habit persistence, in: *Journal of Money, Credit and Banking*, 28(1), 119–129.
- McDonald, I. (ed.) (2012): *Behavioural Macroeconomics*, Cheltenham, UK and Northampton, MA: Edward Elgar.
- Menz, J.-O. (2008): Behavioral macroeconomics and the New Keynesian model, Hamburg University DEP Discussion Paper No 4/2008.
- Mullainathan, S., Thaler, R.H. (2000): Behavioral economics, NBER Working Paper No w7948.
- Noussair, C.N., Pfajfar, D., Zsiros, J. (2015): Pricing decisions in an experimental dynamic stochastic general equilibrium economy, in: *Journal of Economic Behavior and Organization*, 109(C), 188–202.
- Orland, A., Roos, M.W.M. (2013): The New Keynesian Phillips curve with myopic agents, in: *Journal of Economic Dynamics and Control*, 37(11), 2270–2286.
- Pfajfar, D., Žakelj, B. (2014): Experimental evidence on inflation expectation formation, in: *Journal of Economic Dynamics and Control*, 44, 147–168.
- Pigou, A.C. (1929): *Industrial Fluctuations*, London: Macmillan.
- Prescott, E.C. (2006): Nobel lecture: the transformation of macroeconomic policy and research, in: *Journal of Political Economy*, 114(2), 203–235.
- Reis, R. (2006a): Inattentive producers, in: *Review of Economic Studies*, 73(3), 793–821.
- Reis, R. (2006b): Inattentive consumers, in: *Journal of Monetary Economics*, 53(8), 1761–1800.
- Roos, M.W.M., Luhan, W.L. (2013): Information, learning and expectations in an experimental model economy, in: *Economica*, 80(319), 513–531.
- Roos, M.W.M., Schmidt, U. (2012): The importance of time-series extrapolation for macroeconomic expectations, in: *German Economic Review*, 13(2), 196–210.
- Rotemberg, J.J. (1982a): Monopolistic price adjustment and aggregate output, in: *Review of Economic Studies*, 49(4), 517–531.
- Rotemberg, J.J. (1982b): Sticky prices in the United States, in: *Journal of Political Economy*, 90(6), 1187–1211.
- Sargent, T.J. (1993): *Bounded Rationality in Macroeconomics: The Arne Ryde Memorial Lectures*, Oxford: Oxford University Press.
- Sawyer, M. (2010): Crises and paradigms in macroeconomics, in: *European Journal of Economics and Economic Policies: Intervention*, 7(2), 283–302.
- Shefrin, H., Thaler, R. (1988): The behavioral life-cycle hypothesis, in: *Economic Inquiry*, 26, 609–643.
- Simon, H.A. (1972): Theories of bounded rationality, in: McGuire, C.B., Radner, R. (eds), *Decision and Organization*, Amsterdam: North-Holland, 161–176.
- Simon, H.A. (1978): Rationality as process and as product of thought, in: *American Economic Review*, 68(2), 1–16.
- Simon, H.A. (1987): Making management decisions: the role of intuition and emotion, in: *The Academy of Management Executive*, 1(1), 57–64.
- Sonnemans, J., Hommes, C., Tuinstra, J., van de Velden, H. (2004): The instability of a heterogeneous cobweb economy: a strategy experiment on expectation formation, in: *Journal of Economic Behavior and Organization*, 54(4), 453–481.
- Thaler, R.H. (1980): Toward a positive theory of consumer choice, in: *Journal of Economic Behavior and Organization*, 1(1), 39–60.

- Thaler, R.H. (1981): Some empirical evidence on dynamic inconsistency, in: *Economic Letters*, 8(3), 201–207.
- Tobin, J. (1972): Inflation and unemployment, in: *American Economic Review*, 62(1), 1–18.
- Tversky, A., Kahneman, D. (1973): Availability: a heuristic for judging frequency and probability, in: *Cognitive Psychology*, 5(2), 207–232.
- Tversky, A., Kahneman, D. (1974): Judgment under uncertainty: heuristics and biases, in: *Science*, 185(4157), 1124–1131.
- Wärneryd, K.-E. (1982): The life and work of George Katona, in: *Journal of Economic Psychology*, 2, 1–31.
- Weber, C.E. (2002): Intertemporal non-separability and ‘rule of thumb’ consumption, in: *Journal of Monetary Economics*, 49(2), 293–308.
- Woodford, M. (2009): Convergence in macroeconomics: elements of the new synthesis, in: *American Economic Journal: Macroeconomics*, 1(1), 267–279.
- Woodford, M. (2013): Macroeconomic analysis without the rational expectations hypothesis, in: *Annual Review of Economics*, 5(1), 303–346.
- Wren-Lewis, S. (2007): Are there dangers in the microfoundations consensus?, in: Arestis, P. (ed.), *Is There a New Consensus in Macroeconomics?*, Basingstoke, UK: Palgrave Macmillan, 43–60.
- Wren-Lewis, S. (2011): Internal consistency, price rigidity and the microfoundations of macroeconomics, in: *Journal of Economic Methodology*, 18(2), 129–146.