

NEW ECONOMIC WINDOWS

Domenico Delli Gatti • Saul Desiderio  
Edoardo Gaffeo • Pasquale Cirillo  
Mauro Gallegati

# **Macroeconomics from the Bottom-up**



Springer

# Macroeconomics from the Bottom-up

# New Economic Windows

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*To Hy Minsky,*

*who strived to teach us how to get involved with  
non-speculative (no-Ponzi) economic research,  
and how ridiculous economic theorems can be  
when they are detached from the real world*

# Preface and Acknowledgements

The ideas and results in this book represent the culmination of a research project aimed at exploring macroeconomic issues moving from premises alternative to those employed by the current mainstream. The nickname informally assigned to the project – *CATS* – was originally chosen to honour two members of the research group (DDG and MG), as that was the way the lamented Hyman Minsky once baptised them because of an allegedly common zoological root in their family names. After joking on it for some time we realized that *CATS* could also perfectly summarize the deep-rooted methodology inspiring our approach, according to which any economy – and, *a fortiori*, a large industrialized macro-economy – should be modelled as a *Complex Adaptive System* to be analyzed by means of agent-based computational experiments.

The bulk of us (DDG, EG, MG) has already offered a first introduction to the potentialities of an agent-based approach to macroeconomics in another book, *Emergent Macroeconomics* (EM) (Delli Gatti *et al.*, 2008). This new endeavour is partly a follow up, and partly an upgrading. In fact, analogously to EM the key idea we maintain and develop throughout this book is that theoretical representations of macroeconomic phenomena cannot be inferred from the fully predetermined behaviour of a representative agent, whose actions bring him unfailingly to an equilibrium, thanks to the hidden coordinating guide of the Walrasian auctioneer. In contrast to this view, we do believe that a theory of macroeconomic outcomes should be explained as emerging from the continuous *adaptive dispersed interactions* of a multitude of *autonomous, heterogeneous and bounded rational agents* living in a *truly uncertain environment*.

Differently from EM, however, in the framework we shall present in what follows *all* the aggregate variables (price and wage indices, quantities supplied and demanded, interest rates) are endogenously determined through completely decentralized trades. Agents act purposively to discover their *right* individual ask/bid prices and offer/demand quantities, that is the prices and quantities which sometimes clear the small portions of market in which they happen to operate. However, none of them is interested in the properties of the economy as a whole,



let alone in knowing if the system admits a unique and stable aggregate equilibrium. None of them is asked to solve astonishingly difficult optimization problems, simply because the presence of endogenous uncertainty makes such an effort completely unaffordable. On these premises, we build a computational laboratory which allows us to provide a *general* (i.e., multi-market) description of how a macroeconomy evolves in time, but also to keep track of the artificial history of each single agent. In addition to the results we were able to obtain with the approach followed in EM, we are now in a position to address a wider range of typical macroeconomic issues, such as the relationship among output growth, productivity and inflation, or the emergence of wage-price spirals.

As any culmination should be, we hope this book will represent a new start also. Some hints on possible directions for future investigations will be offered in the final chapter. What is more, we look forward to seeing the development and maturity of a “agent-based-macro” community of scholars, focused deeply on the view according to which “[...] the economy is best conceived of as a network of interacting processors, each one with less capacity to process information than would be required of a central processor set to solve the overall allocation problem for the entire system” (Leijonhufvud, 1993). Should this volume contribute a few steps along this perilous but exciting route, our mission would be accomplished.

In this volume we present a lot of unpublished material developed during the last four years, especially regarding the methodological underpinnings of our approach, the sensitivity analysis of the model and validation exercises. The rest derives from articles we have published in the meantime, as “Complex agent-based macroeconomics: a manifesto for a new paradigm” (2010, *Journal of Economic Interaction and Coordination*), “Adaptive microfoundations for emergent macroeconomics” (2008, *Eastern Economic Journal*) and “Reflections on modern macroeconomics: can we travel along a safer road?” (2007, *Physica A*).

The list of people who deserve our thanks for their help during the preparation of this book is very long. At different stages of the *CATS* adventure, we were fortunate enough in profiting from the excellent teamwork secured by Tiziana Assenza, Leonardo Bargigli, Stefano Battiston, Michele Catalano, Fabio Clementi, Giulia De Masi, Corrado Di Guilmi, Marco Gallegati, Gianfranco Giulioni, Umberto Gostoli, Mauro Napoletano, Eniel Ninka, Antonio Palestrini, Matteo Richiardi, Alberto Russo, Emiliano Santoro and Gabriele Tedeschi. Somehow, all of them should be considered accomplices for the product in front of you, in ways perhaps they do not fully recognize. But we do.

We owe a huge intellectual debt (and several dinners) to Bruce Greenwald and Joe Stiglitz, who hosted us at Columbia University many times. The thought-provoking discussions we had with them stimulated and sustained the development of our thinking on this subject. The vision outlined in this work has been also sensibly refined in the course of stimulating conversations with many EURACE friends, in particular Silvano Cincotti and Herbert Dawid.

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Milan, January 2011

*Domenico Delli Gatti*  
*Saul Desiderio*  
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*Mauro Gallegati*

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# Chapter 1

## Introducing *Bottom-up Adaptive Macroeconomics*

People are responding to an environment that consists of other people responding to *their* environment, which consists of people responding to an environment of people's responses. Sometimes the dynamics are sequential ... Sometimes the dynamics are reciprocal ... These situations, in which people's behaviour or people's choices depend on the behaviour or the choices of other people, are the ones that usually don't permit any simple summation or extrapolation to the aggregates. To make that connection we usually have to look at the *system of interaction* between individuals and their environment.

THOMAS C. SCHELLING  
*Micromotives and Macrobehavior*, p. 14

### 1.1 At the Roots of the Mainstream *Weltanschauung*

Contemporary economics is in troubled waters. This is true most of all for that particular area of the economic discourse labeled macroeconomics. Although in our days there exists a consolidated and celebrated mainstream framework known as Dynamic Stochastic General Equilibrium (DSGE) model (Blanchard, 2008; Woodford, 2008), its internal coherence and ability in explaining the empirical evidence are increasingly questioned from several quarters (Colander, 2006; Howitt *et al.*, 2008; Juselius and Franchi, 2007), especially after the turmoil of the first global crises of the XXI<sup>st</sup> century has materialized almost unannounced and misconstrued (Driffill, 2008).

Maybe surprisingly, the causes of the present state of affairs go back at least to the mid of the eighteenth century, when some of the Western economies were twisted by the technological and institutional advancements which led to the industrial revolution, and the new-born *political economy* was still a small portion of moral philosophy striving for disciplinary autonomy. This happened roughly one century after the Newtonian revolution re-founded physics on new grounds: from

the small apple to the enormous planets, all physical objects were found to eventually obey the simple *natural* and *deterministic* law of universal gravitation. It was therefore natural for the then emancipating figure of social scientist (*the economist*) to increasingly borrow the method (*mathematics*) of the most successful and admired among the hard sciences (*physics*), allowing for the mutation of political economy into *economics*. In the end, it was the mechanical physics of the seven-teen century which inspired the marginalist revolution of the 1870s led by Stanley Jevons, Carl Menger and Leon Walras: any explanation of human behavior must be necessarily brought back to that of a selfish *Homo Oeconomicus*, who makes axiomatic-defined rational calculations aimed at maximizing a context-independent utility function.<sup>1</sup> From then on – precisely while in many other domains of human knowledge it was becoming clear that the mechanical model could no longer be considered as universal – economics started to live its own placid disciplinary evolution firmly rooted on the holy trinity of classical physics, i.e. reductionism, determinism and mechanicism.

Quite remarkably, it must be admitted that the probabilistic approach of relativity theory and statistical physics, which deeply shook the foundations of physical sciences at the turn of the nineteenth century, found their authoritative counterparts also in economics during the two decades of *the high theory* (i.e. the 1920s and the 1930s).<sup>2</sup> In two independent contributions published in the same year, Frank H. Knight and John Maynard Keynes made forcefully the point that economic decisions are usually taken in circumstances of radical uncertainty, in which probability statements cannot be deemed as absolute – that is, given once and for all – nor comparable (Knight, 1921; Keynes, 1921). On the contrary, the notion of probability – and, as a consequence, of expectation – is fundamentally relative:

No proposition is in itself either probable or improbable, just as no place can be intrinsically distant; and the probability of the same statement varies with the evidence presented, which is, as it were, its origin of reference. (Keynes, 1921, p. 7)

Albeit largely unnoticed by many of his numerous exegetists, Keynes was largely inspired by relativistic ideas also in his more famous *General Theory* (Keynes, 1936). In this respect, two basic claims can be advanced (Togati, 2001). First, he made a clear distinction between the analysis of individual behavior and that of macroeconomic aggregates, which paralleled the dismissing of atomism and the

---

<sup>1</sup> In the final chapter of his *General Theory*, Keynes (1936) wrote of contemporaneous politicians as intellectual slaves of economists passed away at least a decade before. Extending this metaphor, XXI century economists are intellectual slaves of the mummified physicists of the XVII century (see also Mirowski, 1989).

<sup>2</sup> Phelps (1990) inserts the uprising of the probabilistic approach in economics into the wider intellectual revolution known as *modernism*, a cultural and philosophical approach which transformed the Western world between 1860 and 1930, and that comprises “... the cubism of Picasso and Braque, the atonalism of Schoenberg and Berg, the fragmented poetry of Eliot and Pound, and various writings from Nietzsche to Sartre” (Phelps, 1990, p. 5).

introduction of the concept of field made a few years before by Albert Einstein. In Keynes' words:

The right dichotomy is, I suggest, between the theory of the individual industry or firm [...] on the one hand, and the theory of output and employment *as a whole* on the other one. (Keynes, 1936, p. 293; emphasis in original)

What Keynes argued is that macroeconomic aggregates can be explained if and only if individuals are studied by recurring to a systemic perspective, according to which conventional factors – themselves the unintended products of agents' interactions – instruct and constrain individual behaviors and expectations. Second, in line with the rejection of absolute time and space carried out in modern physics by Einstein, Keynes maintained that conventions – far from being given once for all – are inherently time-contingent. The counterpart of Einsteinian Relativism in Keynesian economics was the explicit acknowledgment that in general agents take decisions by following conventional rules of conduct in conditions of radical uncertainty, and that from time to time the prevailing convention abruptly breaks down:

It is not surprising that a convention, in an absolute view of things so arbitrary, should have its weak points. [...] A conventional valuation which is established as the outcome of the mass psychology of a large number of ignorant individuals is liable to change violently as the result of sudden fluctuations of opinion due to factors which do not really make much difference to the prospective yield, since there will be no strong roots to hold it steady. [...] In abnormal times, the market will be subject to waves of optimistic and pessimistic sentiment. (Keynes, 1936, pp. 153–4)

This does not necessarily imply that agents' behavior should be seen as irrational, nor that some regularity in economic life cannot be detected. On the contrary, different circumstances call for different criteria of individual rationality: in some cases maximization is feasible and practicable, in some others routinized behavior constitutes a best response. Furthermore, while an external observer cannot fully predetermine the causal mechanism that drives individual behavior and market outcomes under those different circumstances, qualitative restrictions on probabilistic representations of change can be used to fruitfully distinguish between alternative explanations of empirical outcomes.

In spite of the exceptional success of its practical implementation during the two decades following the end of the II<sup>nd</sup> World War, however, the theoretical underpinnings of the Keynesian revolution has been never fully grasped inside the profession. This became manifest at the turn of the 1960s, when the neoclassical counter-revolution framed backed the discipline into the traditional marginalist approach and ignored almost by definition any interdependence among agents on the one hand, and any difference between individual and aggregate behavior on the other one. The ideas of natural laws, equilibrium theory and a unified structure of explanation was re-inserted into the theoretical *corpus* of pre-Keynesian economics *sic et simpliciter*, and their combination with rational expectations