



# Introduction to the special issue on two editions of the workshop on economic science with heterogeneous interacting agents, 24.5th Milan, 2021 (WEHIA 2021) 25th Catania, 2022 (WEHIA 2022)

Alessio Emanuele Biondo<sup>1</sup> · Domenico Delli Gatti<sup>2</sup>

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## Abstract

This paper introduces the special issue on two editions of the Workshop on Economic Science with Heterogeneous Interacting Agents, 24.5th Milan, 2021 (WEHIA 2021) and 25th Catania, 2022 (WEHIA 2022).

## 1 25 Years of heterogeneity and interaction

Many years have passed since the first questions arose about the applicability of the standard economic approach to the actual configuration of many market and non-market situations. The orthodoxy of the economic theory has been revisited under many points of view, such as the paradigm of decision-making and the concept of rationality, the existence of equilibrium and the taxonomy of its attributes, the possibility to forecast future dynamics of aggregate economic variables and the reliability of obtained predictions, the meaning of microfoundation in macroeconomics and the related problem of methodological individualism, the aspects of complexity, and the consequences in terms of the role of economic policy.

From a theoretical perspective, macroeconomic variables result from the summation of numerous microlevel variables that represent the activities of individual economic agents. Essentially, a micro–macrolink needs to be established to articulate the theoretical state of an economic system. Despite its apparent simplicity, this point is one of the most crucial in Economics, referring to the definition itself of macroeconomics. The relationship between micro- and macroeconomic variables has been solved by the orthodox theory by proposing a microfoundation for macroeconomics consisting in the creation of a representative agent, who collects all

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✉ Alessio Emanuele Biondo  
ae.biondo@unict.it

<sup>1</sup> Dipartimento di Economia e Impresa, Università degli Studi di Catania, Catania, Italy

<sup>2</sup> Dipartimento di Economia e Finanza, Università Cattolica del Sacro Cuore, Milan, Italy

features of the population. Despite most of the emphasis on this approach comes from the presumption of validity of the methodological individualism, in both theoretical and applied circumstances, a tension toward a deep reconsideration has developed (Colander 2007). Furthermore, a relevant stream of literature highlights that the assumption of coordination of all agents is very strong (Kirman 2016). The simultaneity of actions is not a realistic representation of real macroeconomic systems (Biondo 2023), and addressing key coordination issues is crucial for understanding the impact of policies (Howitt 2012).

Schelling (1971) was one of the pioneers in introducing a complexity approach to social sciences, by suggesting the view that economic systems are inherently complex due to the presence of numerous short- and long-range interactions among agents creating unsolvable differences between the individual and the aggregate levels. This discrepancy makes economics particularly susceptible to fallacies of composition. During the last 25 years, the research in economics has developed aiming to bring within the profession the awareness of pervasive consequences of interdependence, heterogeneity, interactions, complex networks, feedbacks, and contagion effects. Challenged by the view that people do not act in isolation, the economic theory has been opened to interacting agents, who operate according to their heterogeneous features out of the portrait of the general equilibrium. As a result, the approach following the microfoundation of macroeconomics has been shown unable to provide realistic models, for it treats the ensemble of individuals as a unique individual. The aggregate dynamics cannot be studied by collapsing the variety of individual behaviors on to a representative agent.

In 1996, Tesfatsion introduced the term “ACE” (agent-based computational economics) at the Second International Conference on Computing in Economics and Finance, emphasizing the promotion of ABM within the field of economics. In 2023, Tesfatsion defined agent-based computational economics (ACE) as a specialization of “completely agent-based modeling” (c-ABM) for economic systems, depicting processes as open-ended dynamic systems driven by agent interactions, given specific initial conditions. Agent-based modeling (ABM) represents a category of modeling techniques aimed at examining systems where the dynamics emerge from successive interactions between heterogeneous entities. Several authors have explored the origins and provided various interpretations of this class of models, among which, Arthur (2021), Axelrod and Tesfatsion (2006), Axtell and Epstein (1994), Axtell (2000), Axtell and Farmer (2022), Chen (2012), Chen et al. (2012), Chiarella et al. (2002), Chiarella and Iori (2002), Colander (2007), Dawid and Fagiolo (2007), Delli Gatti et al. (2010) and Delli Gatti et al. (2011), Cincotti et al. (2010), Dosi et al. (2010), Epstein (1999) and Epstein and Axtell (1996), Fagiolo et al. (2007), Gallegati et al. (2005), Gilbert (2004), Hommes (2006, 2013), Iori (2002), Kirman (1992, 1993, 1997), and Kirman (2010), LeBaron (2006), Namatame and Chen (2016), Railsback and Grimm (2019), Schelling (1971), Tesfatsion (2002), Tesfatsion and Judd (2006), Wilensky and Rand (2007). In particular, specifically dealing with macroeconomic agent-based models, Dawid and Delli Gatti (2018) provide a comprehensive survey of most acknowledged contributions.

Since 1996, the Society for Economic Science with Heterogeneous Interacting Agents (ESHIA) organizes the annual Conference, called Workshop on Economic

studies with Heterogeneous Interacting Agents (WEHIA), where the above-introduced perspectives related to complexity, heterogeneity, realistic policy models, and, in general, agent-based contributions are presented and discussed among researchers. The 25th edition of WEHIA had been originally scheduled to be organized by Alessio Emanuele Biondo at the University of Catania in 2020. Unfortunately, the spreading pandemic of COVID-19 caused the impossibility of required arrangements for an international conference; thus, it has not been held. In 2021, an online only edition, called 24.5th, has been organized at the Università Cattolica del Sacro Cuore, in Milan, by Domenico Delli Gatti. Finally, in 2022, under restored normal circumstances, the 25th WEHIA has been organized and held in Catania as originally planned. A special thank goes to the keynote speakers of both editions, namely, Eva Camacho Cuenca, Herbert Dawid, Robert H. Frank, and Rosario N. Mantegna, who were originally invited for the edition planned in 2020 and contributed to the 24.5th, and Mauro Gallegati, Laura Gardini, and Alan Kirman, invited for the 25th.

A special thank goes to Alan Kirman for his enlightening discourse at the final Ceremony of the conference. This special issue contains papers from both the 24.5th and the 25th editions, thus virtually keeping together all participants related to the agent-based community involved with the original plan, occasionally perturbed by the extraordinary conditions caused by the pandemic.

## 2 Contributions

Contributions have been heterogeneous and focused on a wide range of topics, among which, the political management of pandemics, the long-term expectation casting, energy sector financing strategies, the relevance of perceptions in systemic risks, climate problems and fads, and the historical retrospective investigation.

Thus, Calcagnini et al. present an evolutionary non-cooperative game between politicians and citizens to analyze the containment policies adopted by governments to mitigate a pandemic. Specifically, they aim to explain why, empirically, during the COVID-19 pandemic, different containment policies were implemented in countries with a similar infection rates, and conversely, why similar policies were applied in countries with vastly different infection rates. They also seek to understand why harsher and softer containment measures alternated. They first present a one-shot evolutionary game in which the government decides whether to implement hard or soft containment, while citizens choose to comply or not. The politicians' payoff is assumed to negatively depend on the infection rate but positively on the fraction of compliant citizens and the fines collected from those who disobey. Citizens observe the government's policy and its duration and then decide whether to comply or not. In the first case, their payoffs depend on the protection gained from potential infection and the losses incurred due to lockdowns (e.g., costs of job loss). In the second case, their utility positively depends on the "satisfaction" of disobedience (the psychological effect of shirking) and negatively on fines and the likelihood of illness. The model is then extended to a dynamic game to study the coevolution of their strategies over time.

Instead, Alfarano et al. aim to assess the effects of small but systematic variations in fundamental value on subjects' short-term and long-term price expectations through a series of Learning to Forecast Experiments. They recruit 336 students and ask them to forecast prices over different time horizons across 20 periods, including both short-term (one-period-ahead) and long-term forecasts. Authors compare a baseline setting, where the fundamental value remains constant, with other scenarios in which it follows time-varying patterns: a linear increase over the 20 periods, an inverse V-shaped pattern, or a V-shaped pattern. In these V-shaped patterns, the fundamental value either rises (falls) linearly for the first 10 periods and then decreases (increases) linearly for the remaining 10 periods. For each pattern of fundamental value, both positive and negative feedback treatments are considered, in order to understand the impact of the feedback system on expectation formation. Their results indicate that, compared to a scenario with constant fundamentals, gradual changes in fundamental values have a limited effect on participants' expectation formation in positive feedback markets. However, in negative feedback markets, significant changes in expectation formation are observed.

Dávila-Fernández et al. propose a switching-strategies growth model to analyze why public perceptions of climate change differ between nations and vary over time. Two types of agents, who can interact with one another, are distinguished considering their sentiment toward the environmental problem: supporters (who understand the importance of climate change and advocate for mitigation strategies) and deniers (who do not see the issue as significant). The model also considers the feedback effects between sentiments, environmental regulation, and macroeconomic outcomes within an open economy framework. Specifically, they study how macroeconomic and ecological conditions can influence sentiments in favor of green policies.

Di Noia aims, instead, to analyze the effect of corporate bonds on the overall economic performance of a society. To do so, a macroagent-based model from the complex adaptive trivial systems family is presented, in which two endogenous credit channels are available for participants in the market: the traditional banking channel and the corporate bond channel. Various simulations were conducted, distinguishing between a baseline scenario that only includes the bank credit channel, scenarios where only households can invest in bonds and scenarios where firms can also create bond portfolios. Bonds that are present are both risky corporate and safe government ones. Results suggest that introducing a bond market could worsen current crises and recessions, and that the bond purchases by firms might amplify inequality.

Further, Bacchiocchi et al. analyze the role of the Central Bank in mitigating risks related to climate change through the implementation of a green monetary policy. In particular, by including in the model a tilting factor that regulates the proportion of green and non-green bonds in the Central Bank's portfolio, they investigate the impact on the market of a shifts from a corporate bond purchasing program that follows a carbon-neutral monetary policy to one based on a green monetary policy. Increasing the share of bonds issued by low-carbon companies leads to a reduction in borrowing costs for environmentally sustainable firms, while raising the financing costs for companies undertaking non-green investment projects. Thus, this green monetary policy should influence firms to invest in and transition toward environmentally sustainable production. Baldauf and Jochem, instead, propose an analysis

of financing mechanisms for renewable energy. They advance an investment model in which energy investors interact in an imperfect and decentralized market network for credits, deposits, and project equity. Agents engage in new power plant investments either through a special purpose vehicle in a project finance (PF) structure or via standard corporate finance (CF). The growth of new power generation capacity is discussed by taking into account technological differences and investment risks associated with the power market, over different scenarios.

Fads have been investigated by Bargigli and Pietrini, who introduce an agent-based model to explore whether fashion cycles are a marginal phenomenon within the economy, affecting only luxury goods and a wealthy class. The model is populated by heterogeneous agents who use goods as a communication tool and exhibit tendencies to both conform and distinguish themselves. Specifically, the agents create fashion cycles if the drive for distinction dominates, or stable groups if conformity prevails. By constructing a model without assumptions about the characteristics of goods or the income distribution, the authors demonstrate that fashion cycles can extend beyond the traditional association of luxury goods and the leisure class. They show that even among the poor, consumerist behavior can emerge.

Finally, Visonà and Riccetti present an agent-based model of the British Industrial Revolution, grounded in Robert Allen's theory (Allen 2009), and explore the role of labor prices in shaping the model dynamics. Following the history-friendly models philosophy, the model replicates the historical context and some counterfactual changes are presented to test its consistency. The model simulates an economy reflecting English society during the Industrial Revolution, with heterogeneous agents interacting by exchanging goods and services. The community is composed of the government and households, which include workers, bourgeoisie (who own firms producing goods or providing services), and nobles (who own farms producing food). Simulations show that interactions among these agents lead to emergent economic phenomena such as nominal GDP growth and inflation. After analyzing this stable pre-industrial economy, the potential for firms to have access to coal, sufficient capital, and sell their stock of goods is introduced. Industrialization is represented by a switch to a different production function, which increases the maximum number of workers a firm can employ. Results show that initial labor prices significantly influence model dynamics, supporting Allen's hypothesis that lower labor prices would have prevented the Industrial Revolution.

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