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Validation of Agent-Based Models in Economics and Finance

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Abstract

Since the survey by Windrum et al. (Journal of Artificial Societies and Social Simulation 10:8, 2007), research on empirical validation of agent-based models in economics has made substantial advances, thanks to a constant flow of high-quality contributions. This Chapter attempts to take stock of such recent literature to offer an updated critical review of the existing validation techniques. We sketch a simple theoretical framework that conceptualizes existing validation approaches, which we examine along three different dimensions: (i) comparison between artificial and real-world data; (ii) calibration and estimation of model parameters; and (iii) parameter space exploration. Finally, we discuss open issues in the field of ABM validation and estimation. In particular, we argue that more research efforts should be devoted toward advancing hypothesis testing in ABM, with specific emphasis on model stationarity and ergodicity.

Keywords

Agent-based models **Validation** **Calibration** **Sensitivity analysis** **Parameter space exploration**

JEL codes

C15 **C52** **C63**

Notes

1. The validation process might also take different perspectives. In particular, as reported by Burton and Obel (1995), the model's assumptions and abstractions have to be judged accordingly with the model's purpose. In this paper, we mostly focus on validation of policy-oriented, descriptive agent-based economic and financial models.

2. However, also other viable strategies are available: see, for example, the calibration approach proposed by Werker and Brenner (2004); Brenner and Werker (2007) and the history friendly models developed by Malerba et al. (1999).

3. In that there is a major departure with respect to neoclassical models, where the

(representative) agent has axiomatic preferences and maximizes some smooth objective function with an easily computable bliss point.

4. This is also one of the critiques that is usually addressed to ACE. Since ABMs do not stick to some generally accepted axiomatic rule of behavior, they introduce discretionary choices that the modeler shall take. We will see how practitioners have coped with this issue in Sect. 31.4.2.1. A possible solution to discipline the construction phase of an ABMs has been put forward by Grimm et al. (2006) and is called the ODD protocol (from “Overview, Design concepts, and Details”).

5. As stated in Turrell (2016), the first agent-based model was developed in the 30s by the physicist Enrico Fermi in order to study the transport of neutrons through matter. Fermi’s agent-based technique was later called Monte Carlo method (Metropolis and Ulam 1949).

6. In Sect. 31.4.2, we will discuss the tools available for the verification and validation of ABMs.

7. One can also study the basins of attraction of the dynamical system to study the robustness with respect to initial conditions.

8. In agent- based modeling, some of the standard validity aspects that are relevant in many fields of numerical simulations are not

an issue; for example, systems are always represented in discrete time and, hence, discretization errors are not possible. Further, low emphasis is usually posed on code verification.

9. See also Secchi and Seri (2017) on the issue of selecting the number of times a computational model should be run.

10. Level 0 models can be somehow accepted if their aim is merely exploratory rather than descriptive.

11. See, for example, Dosi et al. (2010, 2013, 2015, 2016a) for replication of business cycle and growth stylized facts; Dosi et al. (2017a) for accounting of labor-market micro and macro regularities; Popoyan et al. (2017) for the reproduction of many credit and interbank market properties; Lamperti et al. (2018a, b) for capturing coevolution of economic fundamentals with energy and emission quantities; Pellizzari and Dal Forno (2007); Leal et al. (2016) for simulating financial market booms and busts.

12. For a discussion of calibration and testability, see Chap. 40 by Frisch in this volume.

13. Benchmark models are, for example, the Brock and Hommes (1998) asset pricing model and the Kirman (1991) speculative bubbles model.

14. See also Boswijk et al. (2007); Bianchi et al. (2008b); Goldbaum and Mizrach (2008); Franke (2009); de Jong et al. (2010); Franke and Westerhoff (2012); Chiarella et al. (2014); Platt and Gebbie (2016).

15. For robustness of the model, we here mean the stability of the results to small variations of the parameters. See also Lorscheid et al. (2012) and Thiele et al. (2014).

16. See also Chap. 12 by Marks in this volume.

17. For other interesting approaches on pattern-based validation see Barde (2016b) and Marks (2018).

18. VAR-LiNGAM stands for Vector Autoregressive Linear Non-Gaussian Acyclic Model.

19. Coupling NOLH with kriging meta- modeling has been frequently used to approximate the output of computer simulation models (see, for example, McKay et al. 1979; Salle and Yıldızoğlu 2014; Bargigli et al. 2016).

20. The interested reader might want to look at Thiele et al. (2014) for a cookbook guiding model exploration and sensitivity and Grimm et al. (2005) for a pattern-oriented approach at model building and evaluation.

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