Complexity and policy analysis in macroeconomics

Tobias Henschen, University of Cologne

Abstract (832 words, excluding references)

The paper argues that the macroeconomy is a complex system, and that agent-based models are likely to become the leading tool for policy analysis in macroeconomics. That the macroeconomy is a complex system is supposed to mean that it exhibits the features that many theorists believe are necessary for the complexity of a system as well as features that these theorists believe many complex systems exhibit (cf. Hooker 2011, pp. 20-40, Ladyman & Wiesner, chap. 3). The necessary features include the numerosity of system components and their direct interactions, disorder (or lack of correlation), feedback (the dependence of direct interactions on earlier ones), dynamic nonequilibrium (no steady states), spontaneous order (the emergence of conditional and unconditional probability distributions), nested structure (the hierarchical organization of system levels), and adaptive behavior. Among the non-necessary complexity features we find features like the heterogeneity of system components and nonlinearity.

That the macroeconomy is a complex system should be relatively uncontroversial among macroeconomists. Some of the complexity features of the macroeconomy (numerosity, feedback, nested structure, adaptive behavior, heterogeneity, and nonlinearity) present themselves to an unbiased view. The remaining ones (disorder, spontaneous order, dynamic non-equilibrium) are backed up by theoretical considerations. Like any other complex system, the macroeconomy exhibits disorder at the level of initial conditions and emerging order when initial conditions are updated. The feature of dynamic nonequilibrium is supported by the theorems of Sonnenschein (1973), Mantel (1974), and Debreu (1974), and by the fact that no empirical evidence speaks in favor of the convergence of the macroeconomic system toward any steady state (cf. Kirman 2016). It is also worth mentioning that most of the features of complex systems (numerosity, disorder, spontaneous order, heterogeneity, adaptivity) come in degrees. Consider adaptivity, which in macroeconomics comes down to the ability of agents to correct past errors when forming expectations. Since adaptivity comes in degrees, it doesn't rule out that some agents form rational expectations at least some of the time.

When conducting policy analysis, macroeconomists have a whole spectrum of models at their disposal. At one extreme we find the canonical dynamic stochastic general equilibrium (DSGE) model, which models the macroeconomy as a system that is fully noncomplex: as a system that doesn't exhibit the features of numerosity (few representative agents interact indirectly via a price mechanism), heterogeneity (the representative agents are homogeneous optimizing agents), disorder (the behavior of the optimizing agents is correlated), feedback (all behavior is forward-looking, there is no habit formation), non-equilibrium (the system is kicked out of equilibrium only temporarily by exogenous shocks), nonlinearity (there are log-linear approximations to equilibrium solutions), spontaneous order (the system is ordered from the get-go), nested structure (the level of macroeconomic aggregates fully reduces to the level of microeconomic quantities), or adaptive behavior (the representative agents form rational expectations).

At the other extreme, we find agent-based models, which (like the Keynes + Schumpeter model of Dosi et al 2017) model the macroeconomy as a system that exhibits all the complexity features mentioned above: as a system that is populated with myriads of heterogenous agents who behave adaptively, and who interact directly in dynamic non-equilibrium such that earlier

interactions feed back into later ones and stylized facts (conditional and unconditional probability distributions of the values of micro- or macroeconomic variables) emerge. Between the two extremes, there are some agent-based models and the various DSGE models used in policymaking institutions (models of a macroeconomic system that exhibits only some of the complexity features mentioned above).

Like other scientific models, macroeconomic models simplify to a substantial degree. But while some of the best agent-based models simplify only by approximating, the other models in the spectrum simplify by both approximating and idealizing. One may say that models approximate when substituting a true numerical value with a simpler one, and that they idealize when substituting (parts of) the target system with (parts of) a different (and fictional) system (cf. Teller 2009, section 4, Norton 2011). Of all models in the spectrum, the canonical DSGE model is the one that idealizes to the highest possible degree because it replaces the complex macroeconomy with a system that is fully noncomplex.

All by itself, a high degree of idealization does not imply that idealizing models cannot be successfully employed for purposes of policy analysis. But success is relative, and models should be discarded if competing models can be employed more successfully. Present-day DSGE models are unlikely to outperform present-day agent-based models in terms of policy analysis, and vice versa. But agent-based models are likely to outperform DSGE models at some point in the future. The reason is that agent-based models have the potential to model explicitly the chains of relations of causal dependence and supervenience (or constitution) that policymaking institutions exploit as a matter of fact. DSGE models lack this potential because they model the macroeconomy as a system without dynamic non-equilibrium or nested structure (because they fail to distinguish a level of macroeconomic aggregates and a level of microeconomic quantities).

References

Debreu, G. (1974). “Excess demand functions.” *Journal of Mathematical Economics* 1(1), 15-21.

Dosi, G., Napoletano, M., Roventini, A., Treibich, T. (2017). “Micro and macro policies in Keynes+Schumpeter evolutionary models.” *Journal of Evolutionary Economics* 27, 63-90.

Hooker, C. (2011). “Introduction to Philosophy of Complex Systems: A + B.” In C. Hooker (ed.), *Philosophy of Complex Systems*. Oxford: North Holland, 3-90, 841-909.

Ladyman, J. & Wiesner, K. (2020). *What Is A Complex System?* New Haven: Yale University Press.

Mantel, R. (1974). “On the characterization of aggregate excess demand.” *Journal of Economic Theory* 7(3), 348-353.

Norton, J. D. (2012). “Approximation and idealization: why the difference matters.” *Philosophy of Science* 79(2): 207-232.

Sonnenschein, H. (1973). “Do Walras’ identity and continuity characterize the class of community excess demand functions?” *Journal of Economic Theory* 6(4), 345-354.

Teller, P. (2009). “Fictions, fictionalization, and truth in science.” In M. Suarez (ed.), *Fictions in science: philosophical essays on modeling and idealization*. London: Routledge, 235-247.