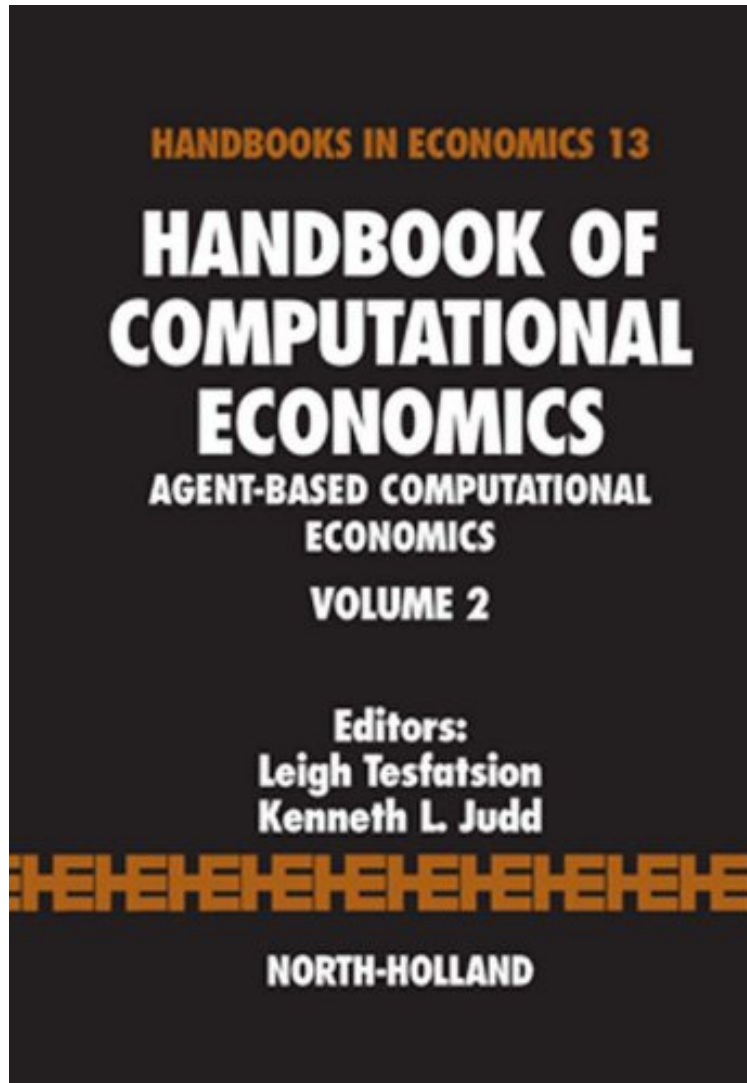


Handbook of Computational Economics: Agent-Based Computational Economics: 2

Leigh Tesfatsion

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Leigh Tesfatsion : Handbook of Computational Economics: Agent-Based Computational Economics: 2 before purchasing it in order to gauge whether or not it would be worth my time, and all praised Handbook of Computational Economics: Agent-Based Computational Economics: 2:

40 of 40 people found the following review helpful. An Invaluable Resource for Practicing and Novice Agent-based Modelers By Herbert Gintis This excellent volume should be entitled "Explorations in Agent-Based Modeling," as a comparison with Volume I of the Handbook of Computational Economics should make clear. The earlier volume is an extremely mature product summarizing the application of computer-intensive mathematical techniques to traditional

economic problems--a subject the history of which goes back to the earliest applications of computers during World War II. The volume under review, Volume II, has a completely different character. Agent-based modeling is a young and vigorous, rather than a mature and technically plodding science. Mathematics, rather than being the central focus, tends to be rather a simple-minded tool, and the programming, rather than being of the number-crunching variety, tends to be a versatile and imaginative mirroring of real-world processes in silicon life-forms and object-oriented structures. The subject matter, moreover, is not limited to the bread and butter of traditional economics (computable general equilibrium, solving for Nash equilibria, macroeconomic modeling, parallel computation, dynamic programming, and the like), but rather explores novel themes in the interface between economics and the other behavioral sciences--especially in this volume politics, biology, and ecology. The chapters do accomplish fairly comprehensive literature reviews (but beware--in this fast-moving field some of the most important contributions are likely to be the most recent, and hence not referenced), but they are rarely technically detailed summaries of the state-of-the-art. Rather, chapters tend to develop themes that are particularly interesting to the author. This makes for a very readable volume, but I am not sure the appellation "Handbook" is truly appropriate. Tesfatsion's first sentence in her introductory essay to the volume gets right to the point. "Economies," she asserts, "are complex dynamic systems." What, we may ask, makes an economy a complex dynamic system? For one thing, the complex economy is never in equilibrium, but is constantly subjected to shocks, both exogenous and endogenous, that affect its short-term movements. There are frequent local nonlinear resonances that lead to significant deviations of economic variables (prices, quantities, wages, asset prices) from their equilibrium values even in the absence of strong or systematic perturbations to the system. We see such deviations in many economic time series, which often have the "fat tails" characteristics of the power laws of complex systems, as opposed to the Gaussian distributions of Neoclassical theory. Second, in a complex (a.k.a. real-world) economy, the Law of One Price fails. For instance, in the European Union, the standard deviation of prices rose from 12.3% in 1998 to 13.8% in 2003, despite the extensive dropping of trade barriers and movement to a common currency over this period. A third characteristic of the complex economy is that it rarely, if ever, achieves the sort of optimality that can be attained in simple engineered systems. For instance, since economies are rarely in equilibrium, most production, trade, and consumption takes place out of equilibrium, and hence is Pareto-suboptimal, at least when measured against a complete information Walrasian economy that has somehow attained equilibrium. It is evident, then, that standard Neoclassical economic theory, as taught in the college and graduate textbooks and developed in the mainstream economics journals, does not recognize that the economy is a complex dynamic system. If the first volume of this pair of Handbooks might be called "how to do traditional economics better with computers," the volume under consideration could be called "How to transform economic theory using agent based modeling." We can chart the following characteristics of the complex economy: (a) The complex economy is thermodynamically open, dynamic, nonlinear, and generally far from equilibrium, whereas the Walrasian economy is thermodynamically closed, static, and linear in the sense that it can be understood using algebraic geometry and manifold theory; (b) In the complex economy, agents have limited information and face high costs of information processing. However, under appropriate conditions, they evolve non-optimal but highly effective heuristics for operating in complex environments. There is no assurance that when faced with novel environments, individuals will shift efficiently to new heuristics. In the Neoclassical economy, by contrast, agents have perfect information and can costlessly optimize; (c) Agents in the complex economy participate in sophisticated overlapping networks that allow them to compensate for having limited information and facing formidable information processing costs. In the Walrasian economy, agents do not interact at all. Rather, each agent faces an impersonal price structure; (d) In the complex economy, macroeconomic patterns are emergent properties of micro-level interactions and behaviors, in the same sense as the chemical properties of a complex molecule, such as carbon, is an emergent property of its nuclear and electronic structure, or that thermodynamics is an emergent property of many-particle systems. In such cases we cannot analytically derive the properties of the macro system from those of its component parts, although we can apply novel mathematical techniques to model the behavior of the emergent properties. In the case of the complex economy, these higher level modeling constructs are currently largely absent, although agent-based modeling may provide the data needed to develop the appropriate mathematical tools. By contrast, the Walrasian economy has no macro properties that cannot be derived from its micro properties (for instance, the First and Second Welfare Theorems); (e) In the complex economy, the evolutionary process of differentiation, selection, and amplification provides the system with novelty and is responsible for the growth in order and complexity. In the Walrasian economy there is no mechanism for creating novelty or growth in complexity. In his chapter in this book, Axel Leijonhufvud develops the insight that many contributions to economic theory from the Marshallian tradition, effectively eclipsed by the influence of Edgeworth, Walras, and their general equilibrium successors, are echoed and developed in the agent-based simulations of economic dynamics. Several authors address the question as to the epistemological status of agent-based models. It is indicative of the youth of this brand of research that widely divergent answers are offered. One such view is that agent-based modeling is an alternative to formal analytical economic theory. It strikes me that this is not at all the case. Rather, an agent-based model is a set of empirical data, and building such models is akin to laboratory experimentation. One can use the results of such experimentation to

inspire theorists to construct analytical models in which one can derive logically the properties of the system observed in the laboratory. Or, if the complexity of the system precludes analytical modeling, one can make broad generalizations based on a comparative study of different agent-based systems. In principle, an agent-based model could provide an existence theorem for a particular emergent phenomenon, but in general there are sufficient differences between a mathematical model of a process and its agent-based implementation (for instance, real numbers are approximated by fixed-precision floating point numbers, and random numbers are approximated by deterministic algorithms with long periods), that the two models could have substantively different properties. Representing ABM models as empirical rather than theoretical contributions is likely to improve the chances for publication in mainstream journals, and hence improve the communication among economists. Economic theorists often make the point to me that in reading an analytical paper, the assumptions and the method of proof are completely transparent, while an agent-based model must be taken on faith, since the model itself is not presented in a journal article, nor would it make much sense if it were, except to an expert in the computer language used. If the ABM is presented as a contribution to theory, it is easy to see why it is rejected by respectable journals: it is asking the reader to take the authors' assertions on faith alone. If the ABM results are represented as empirical data, this problem disappears. When agent-based models are not accepted in mainstream economics journals, modelers tend to place the blame on the closed-mindedness and traditionalistic mentality of the reviewers. I consider this a very serious error, because it gives the agent-based modeler no means of correcting the problem. I think that it is almost always good advice to blame yourself when a paper is rejected, because you are the only one with an incentive to change to meet the reviewers' criteria the next time around. The authors in this volume do not make this mistake, and several have valuable suggestions as to how agent-based models must be crafted to increase their scientific value (Robert Axelrod's suggestions are particularly incisive). It is interesting that none of the authors appears to have noticed the inverse problem: agent-based models are all the rage in some circles, and many faulty models get past reviewers and are published in top journals, including *Science* and *Nature*. The fact is that if two researchers are given the same specifications and write the computer code independently, there is a very good chance their models will differ in substantial ways. There is simply no way for a reviewer to assess the quality of a simulation without spending a considerable amount of time going over the code. Moreover, I have found that researchers often bias code generation in such a way as to support their pet theories. The nature of this bias often cannot be revealed without a thorough inspection of the computer code. This sort of author behavior is not necessarily due to our dishonesty, but rather due to our capacity to self-delude. If the ABM behaves the way we want it to, we leave the code alone. If it does not, we work over it to find out why. The resulting code is thus virtually certain to be self-serving and biased. I do not know how to get around this problem. It is reminiscent of a similar problem with econometric research with complex data sets, where it is virtually impossible for reviewers to ascertain the significance of the results, especially in the case of economic time series. In the case of econometric analysis, the problem is attenuated if researchers are obligated to place the data in the public domain, making replication feasible. In the case of agent-based models, there is usually no "data" different from the model itself. It would be a step forward to require researchers to place their code in the public domain, so that the threat of public scrutiny might serve to attenuate the temptation to torture the code whose results one does not like, while coddling the code that reinforces our prejudices and expectations. Another important issue not systematically addressed in this Handbook is the mechanics of producing an agent-based model. If the researcher does not do his or her own programming, clearly the researcher should generate a completely unambiguous set of specifications for programming the model. However, if the researcher does not know computer programming, this is impossible in all but the most simple cases. Even if the researcher is an expert programmer, he or she cannot pre-visualize exactly how the model should function, since often one tries several alternatives for each piece of code, and one often does not know what the real dynamics of the model are until one has done considerable hands-on programming. For this reason, if I had my way, I would never accept a paper for publication that was not programmed by the researchers themselves, except for the simplest sort of models. Therefore, I believe training in ABM should include training in computer programming to the point of professional proficiency. I do not even accept using canned ABM software, because it is difficult to tell what the software is doing, the implementation is always painfully slow compared to a real computer language, and there are strict limits as to what can be accomplished with such software. However, I know that many leading ABM researchers disagree with this, and happily teach their students to use Swarm, StarLogo, and the like. Until this issue is thoroughly investigated and the truth sorted out from the myth, ABM will remain of limited value to the economic research community. I commend the Editors for doing a fine job in addressing the needs of the ABM community, while producing a volume that can be profitably read by those new to the field. Nevertheless, there remain hard problems that must be soberly addressed before ABM becomes a standard part of the repertoire of economic researchers, and ABM results appear widely in top economics journals.

The explosive growth in computational power over the past several decades offers new tools and opportunities for economists. This handbook volume surveys recent research on Agent-based Computational Economics (ACE), the computational study of economic processes modeled as dynamic systems of interacting agents. Empirical referents for

"agents" in ACE models can range from individuals or social groups with learning capabilities to physical world features with no cognitive function. Topics covered include: learning; empirical validation; network economics; social dynamics; financial markets; innovation and technological change; organizations; market design; automated markets and trading agents; political economy; social-ecological systems; computational laboratory development; and general methodological issues. *Every volume contains contributions from leading researchers* Each Handbook presents an accurate, self-contained survey of a particular topic *The series provides comprehensive and accessible surveys