Empirical Validation Issues for Agent-Based Computational Economics

Presenter:

Leigh Tesfatsion

Professor of Economics and Mathematics

Department of Economics

Iowa State University

Ames, Iowa 50011-1070

http://www.econ.iastate.edu/tesfatsi/

tesfatsi@iastate.edu

Outline

- Redux: Three strands of ACE Research
- For which strand(s) is empirical validation appropriate?
- Does one approach work for all?
- Summary of arguments and open issues from Fagiolo, Windrum, and Moneta (2006)
- Other important issues related to the empirical validation of ACE models

Three Strands of ACE Research

- **Qualitative Insight/Theory Generation**
  (e.g. coordination in decentralized markets,…)
- **Empirical Understanding**
  (e.g. possible reasons for empirical regularities,…)
- **Normative Understanding**
  (e.g. institutional design,…)

ACE and Qualitative Analysis

Illustrative Issue: What are the performance capabilities of decentralized markets? *(Adam Smith, F. Hayek, …)*

ACE Approach:

- Construct an ***agent-based world*** qualitatively capturing key aspects of decentralized market economies (firms, consumers, limited information, …)
- ***Introduce traders with endowments, needs, wants,….*** Let the world evolve. Observe the degree of coordination that results.

EXAMPLES: Decentralized exchange economies without a Walrasian Auctioneer, ZI agent double-auction markets,…

ACE and Empirical Regularities

Key Issue: Is there a causal explanation for **persistently observed empirical regularities?**

ACE Approach:

- Construct an ***agent-based world*** capturing salient aspects of the empirical situation.
- Investigate whether the empirical regularities can be ***reliably generated*** as outcomes in this world.

Example: ACE financial market research seeking explanation of several "stylized facts" in combination
www.econ.iastate.edu/tesfatsi/afinance.htm

ACE and Institutional Design

Key Issue: Does an institutional design ensure **efficient, fair, and orderly social outcomes over time** despite possible attempts by participants to "game" the design for their own personal advantage?

ACE Approach:

- Construct an ***agent-based world*** capturing salient aspects of the institutional design.
- ***Introduce agents with endowments, needs, goals, beliefs, etc.*** Let the world evolve. Observe and evaluate resulting social outcomes.

EXAMPLES: Design of matching mechanisms, unemployment benefit programs, electricity markets

Key Distinctions in Approaches to the Empirical Validation of ACE Models

- **Descriptive output validation**, i.e., matching computationally generated output against already-acquired real-world system data.
- **Predictive output validation**, i.e., matching computationally generated output against yet-to-be-acquired real-world system data.
- **Input validation**, i.e., ensuring that the structural conditions, institutional arrangements, and behavioral dispositions incorporated into a model capture the salient aspects of a real-world system under study.

Empirical Validation of Agent-Based Models

Giorgio Fagiolo
University of Verona, Italy
Sant'Anna School of Advanced Studies, Pisa, Italy
https://mail.sssup.it/~fagiolo

Alessio Moneta
Sant'Anna School of Advanced Studies, Pisa, Italy

Paul Windrum
Manchester Metropolitan University Business School, Manchester, U.K.
MERIT, University of Maastricht, The Netherlands

ACEPOL 2005
International Workshop on 'Agent-Based Models for Economic Policy Design'
Bielefeld, July 2005

Empirical Validation in Neo-Classical Models

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- A lot of different, competing approaches do exist…
  - Haavelmo-Cowles (1944) Approach
  - Structural Modeling Approach (Hansen and Sargent, 1980)
  - VAR Approach (Sims, 1980)
  - Calibration Approach (Kydland and Prescott, 1982)
  - LSE Approach (Hendry, 1988)

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- Some remarks on validation approaches in NCM …
  - Validation is not employed to assess empirical validity of "core" theoretical assumptions (as often happens also in ABMs)
  - Heterogeneity of approaches partly reflects the open debate on validation in "philosophy of economics" (J.S. Mill; Friedman; Hutchinson, Blaug; McKloskey, Mirowski; Lawson, Mäki; etc.)

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- Is available data sufficient?
  - Need for additional, more detailed microeconomics data
  - Need to validate microeconomic foundations with experimental data

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- A pessimistic view about empirical validation?
  - Socio-economics: open-endedness, interdependence, structural change
  - Precise quantitative implications are difficult to obtain

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- Four-Step Procedure (Fagiolo et al., 2004)
  - **Step 1**: Identifying set of SFs of interest to be explained/reproduced
  - **Step 2**: Keep microeconomics as close as possible to "real-world"
  - **Step 3**: Find parameters and initial conditions for which the model is statistically able jointly to replicate the set of SFs
  - **Step 4**: Investigation of subspace of parameters and initial conditions which "resist" to Step 3 in order to seek for causal relationships (explanations)

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- Three-Step Procedure
  - **Step 1**: Employ empirical knowledge to calibrate initial conditions and parameters ranges
  - **Step 2**: Further restricting initial conditions and parameters space by empirically validate simulated output with real-world data
  - **Step 3**: Abduction. Seek explanations of the phenomena under study by exploring properties of the "possible worlds" that resist to previous steps

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- Prominent role for empirical data
  - Detailed empirical (historical) data on the phenomenon under study assisting model building and validation
  - Specify agents' representation
  - Identify parameters and initial conditions
  - Empirically validate the model by comparing "simulated trace histories" with "actual history" of an industry

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- How to employ empirical observations?
  - Assisting in model building (agents, behaviors, interactions,…)
  - Calibrating initial conditions and parameters
  - Validating simulated output
- What to do first?
  - First calibrate, then validate
  - First validate, then calibrate
  - Validate only

Input Validation via Iterative Participatory Modeling

- Joining together with industry stakeholders and researchers from multiple disciplines in a repeated looping through 4 stages of analysis:
  - Field work and data collection;
  - Scenario discussion/role-playing games;
  - Agent-based model development;
  - Intensive computational experiments.

NOTE: See Barreteau et al. (JASSS, 6-1,2003)

Other Issues Related to the Empirical Validation of ACE Models

- How can researchers provide **summary reports** of model findings to other researchers and to intended model users (e.g. policy makers) in an accurate, compelling, and clear manner?

  For example, it might be necessary to report outcome distributions rather than simple outcome point predictions.

  Or it might be necessary to report how network interaction patterns vary systematically in response to policy changes.

Other Issues…Continued

- How can researchers ensure the **robustness** of their model findings?

  For example, how to be sure that model findings indeed arise from modeled attributes of a real-world system under study rather than from spurious aspects of the software/hardware platform implementation?

- How can researchers ensure the **accumulation** of empirically supported findings?