Agent-Based Economic Models and Econometrics

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August 25, 2008

Abstract

This paper reviews the development of agent-based (computational) economics (ACE) from an econometrics viewpoint. The review comprises of three stages, characterizing the past, the present, and the future of this development. The first two stages can be interpreted as an attempt to build the econometric foundation of ACE, and, through that, enrich its empirical content. The third stage may then invoke an reverse reflection on the possible agent-based foundation of econometrics. While ACE modeling has been applied to different branches of economics, the one, and probably the only one, which is able to evidence this three-stage development is finance or financial economics. We, therefore, will focus our review only on the literature of agent-based computational finance, or more specifically, agent-based modeling of financial markets.

The first two stages, namely, *the econometric influence to ACE*, examine the econometric practice in ACE modeling. The first stage, entitled with "*presenting ACE with econometrics*," is to use econometrics to analyze the data generated from the ACE models, and see whether they are able to display a number of frequently observed empirical features, i.e., to replicate or grow "stylized facts." At this stage, the efforts are made to fine-tune the ACE model by matching the statistical properties of the real data with those of the artificial data to a qualitative precision. For example, if the real data exhibits the feature of volatility clustering, can a specific ACE model with a proper design generate the data sharing the same feature? As we frequently experienced, there may be many designs which are capable to feature the same stylized fact; however, attempts to distinguish them were only made at the later (second) stage.

The concept of "optimizing" ACE models with real data characterizes the development of the next stage, which is entitled with *"building ACE with econometrics."* In this stage, econometrics is used *directly* or *indirectly*, *top-down* or *bottom-up,* to estimate or calibrate ACE models. The attempt is to make ACE models can replicate the stylized facts to a degree of quantitative precision, and, even more ambitiously, to use ACE models to forecast the future.

The last part of the paper examines the above link in a reverse direction, i.e., looking at *the influence of ACE to econometrics.* In this third stage, entitled with *"emerging econometrics with ACE,"* econometrics is still applied to the artificial data generated by ACE; however, instead of replicating the macroscopic structure, we examine whether macroscopic structure described by the econometric results from the artificial data can be, in a sense, consistent with the micro-structure. This brings us to the elusive quest of a representative agent and the associated economic conditions for consistency in aggregation, an issue well discussed in both economic theory and econometrics.

It is found that the models with simple heterogeneity and simple rules (few-typemodels), particular those variations of the fundamentalist-chartist model, are sufficient enough to replicate a number of stylized facts. Making this model complex may gain additional explanation power, but so far this power has been well exploited. In addition, the simple model makes the later econometric estimation much feasible.

Econometric estimation of the agent-based financial market models is an ambitious task. In principle one can identify various details of agents, such as their beliefs, memory, intensity of choice, risk perceptions, risk aversions, etc. It may also help us to infer the underlying fitness function, e.g., profits vs. risk-adjusted profits, from the data. For the few-type model, one can further discover the evolving market fractions so as to track the mood of the market. Nevertheless, before we reap fruits from these models, there is still a long way to go. So far, we have been assured that this agent-based financial market models are econometrically significant, and the estimates are stable. One of difficulties in front of us is how to tackle effectively with the numerical aspects of the estimation of complex objective function involving a large number of parameters.

However, the value of agent-based models should not be very much restricted to just replication or validation. This is particular so when the econometrics to support quality validation is still lacking. Treating agent-based models as theoretic models, which behaves as many other stochastic simulation models, can help us to examine the power of the established econometric tests. This function can be most valuable when the environment is filled with various degree of polluted or missing data. The paper therefore ends up with the message that agent-based foundation of econometrics is the next stage to move.

Keyword: Agent-Based Economics, N-Type Designs, Autonomous-Agent Designs, Econometrics, Simulation-Based Econometrics, Market Fraction Hypothesis