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Risk preference, forecasting accuracy and survival dynamics: Simulations based on a multi-asset agent-based artificial stock market☆

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Abstract

The relevance of risk preference and forecasting accuracy to the survival of investors is an issue that has recently attracted a number of theoretical studies. By using agent-based computational modeling, this paper extends the existing studies to an economy where adaptive behaviors are autonomous and complex heterogeneous. Specifically, a computational multi-asset artificial stock market corresponding to Blume and Easley [Blume, L., Easley, D., 1992. Evolution and market behavior. Journal of Economic Theory 58, 9–40] and Sandroni [Sandroni, A., 2000. Do markets favor agents able to make accurate predictions? Econometrica 68, 1303–1341] is constructed and studied. Through simulation, we present results that contradict the market selection hypothesis.

JEL classification: G14

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1. Introduction

Agent-based computational economic (hereafter ACE) modeling is distinguished from the conventional economic modeling by its great flexibility in terms of agents' *heterogeneity* and the associated *population dynamics*. This advantage may be very helpful in studying the *survivability* of different types of agents, specifically when they are placed in a complex interactive environment. In this paper, the ACE approach is applied to address a debate that can be related to the *market selection hypothesis*, according to which markets favor rational traders over irrational traders (Alchian, 1950; Friedman, 1953).

The debate, if we trace its origin, started as a result of the establishment of what become known as the *Kelly criterion* (Kelly, 1956), which basically says that a rational long run investor *should* maximize the expected growth rate of his wealth share and, therefore, should behave as if he were endowed with a logarithmic-utility function. In other words,

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the Kelly criterion implicitly suggests that there is an optimal preference (rational preference) that a competitive market will select and that is *logarithmic-utility*. The debate on the Kelly criterion has a long history, so not surprisingly, there is a long list of both pros and cons with regard to it as the literature develops.[1]

A possible implication of the Kelly criterion is that an agent who maximizes his expected utility under the *correct* belief may be driven out by an agent who maximizes his expected utility under an *incorrect* belief, simply because the former does not maximize a logarithmic-utility function, whereas the latter does. Blume and Easley (1992) were the first to show this implication of the Kelly criterion in a competitive asset market. In their seminal study, they questioned the survivability of rational investors. In a nutshell, they showed that *rational investors* who are characterized by their selection of a portfolio that maximizes their expected utility with respect to the correct belief may not be good enough to survive. To enhance their survivability, their preference over risk (utility function) must also be "optimal." If not, an even more striking result is that these rational agents may be driven out of the market by those agents who base their decisions on *incorrect beliefs*, but have a "nearly optimal" preference.[2]

The market selection hypothesis, therefore, fails because agents with accurate beliefs are not necessarily selected. A consequence of this failure is that asset prices may not eventually reflect the true value of the asset and may fail to converge to the *rational expectations equilibrium*.

Nonetheless, a series of recent studies indicates that the early analysis of Blume and Easley (1992) is not complete. Sandroni (2000) shows that, if the saving behavior is endogenously determined, then the market selection hypothesis is rescued, and in the long-run, only those optimizing investors with *correct beliefs* survive. The surviving agents do not have to be log-utility maximizers, and they can have diverse preferences over risk. Sandroni's analysis is further confirmed by Blume and Easley (2006) in a connection of the market selection hypothesis to the *first theorem of welfare economics*. They show that in a dynamic complete market *Pareto optimality* is the key to understanding selection for or against traders with correct beliefs: in any optimal allocation the survival or disappearance of a trader is determined entirely by beliefs and not by risk preference.

Sandroni (2000)'s and Blume and Easley (2006)'s studies are largely analytical. They both take a Pareto optimal allocation as a starting point to work with. The dynamic process converging to a Pareto optimal allocation itself is, nonetheless, beyond the scope of their analysis. Issues related to the dynamic process are twofold. First, there is *individual dynamic optimization*. A Pareto optimal allocation rests upon the optimization of all individuals. In this specific context, this requires that all agents are able to solve the infinite-time stochastic dynamic optimization problem facing them, regardless of their preferences over risk or utility functions. However, analytical solutions known to us are severely restricted to certain classes of preferences. In general, one has to rely on numerical approximation, which means that Pareto optimality may not always be attainable.

What makes this problem even more complex is, however, the second issue: *trading at an equilibrium consistent with price expectations*. Notice that what we study here is not a simple representative-agent optimization problem, but a market composed of heterogeneous agents. Each one of them, upon maximizing his expected utility, has to know the prices of assets in the future. These prices are, nonetheless, endogenously generated by agents' own perceptions. As a result, a typical fixed-point problem occurs. The market, as a distributed decentralized processor, may fail to coordinate its participants to such a fixed point. In general, it will depend on agents' forecasting rules and the associated learning schemes, and it is likely that agents will trade at prices that are inconsistent with their *ex ante* expectations of the prices. In this case, Pareto optimality is also not attainable.

Both of the two issues discussed above are directly related to the attainability of Pareto optimality. However, Pareto optimality per se was only taken by Sandroni and Blume and Easley as a convenient starting point for their analytical work. To facilitate their further analysis, the learning dynamics concerned with the updating of agents' beliefs are also needed to be simplified. Sandroni, for example, did not deal with learning dynamics directly; instead, he assumed that there will be a day when *some agents can eventually make accurate predictions* or *eventually make accurate next period predictions* and started his major analytical work from there. Nevertheless, a plausible process to show the appearance of these *sages* was absent. It is, therefore, not entirely clear whether these types of agents will ever emerge. What happens when no trader has correct beliefs?[3]

[1] See Sciubba (2006) for a quite extensive review.

[2] Other similar findings can also be found in Sciubba (2006).

[3] Sandroni does consider the case when no one has correct beliefs. His Proposition 3 basically compares two kinds of agents: one persistently forecasts more accurately than the other, while neither has correct beliefs. He then shows that the former