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Agent-based computational modeling of the stock price–volume relation

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Abstract

From the perspective of the agent-based model of stock markets, this paper examines the possible explanations for the presence of the causal relation between stock returns and trading volume. Using the agent-based approach, we find that the explanation for the presence of the stock price–volume relation may be more fundamental. Conventional devices such as information asymmetry, reaction asymmetry, noise traders or tax motives are not explicitly required. In fact, our simulation results show that the stock price–volume relation may be regarded as a generic property of a financial market, when it is correctly represented as an evolving decentralized system of autonomous interacting agents. One striking feature of agent-based models is the rich profile of agents' behavior. This paper makes use of the advantage and investigates the micro–macro relations within the market. In particular, we trace the evolution of agents' beliefs and examine their consistency with the observed aggregate market behavior. We argue that a full understanding of the price–volume relation cannot be accomplished unless the feedback relation between individual behavior at the bottom and aggregate phenomena at the top is well understood.

Keywords: Agent-based model; Artificial stock markets; Genetic programming; Granger causality test; Stock price–volume relation; Micro–macro relation

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1. Motivation and introduction

The agent-based modeling of stock markets, which originated at the Santa Fe Institute [2,47], is a fertile and promising field that can be thought of as a subfield of agent-based computational economics (ACE). [1]Up to the present, most of the research efforts have been devoted to the analysis of the *price dynamics* and/or *market efficiency* of the artificial markets (e.g. [13,14,44,57]). Some studies have focused on the price deviation or mis-pricing in the artificial stock markets (e.g. [2,8,10,12,43,44,47,56]). Some have gone further to explore the corresponding *micro-structure* of the markets, such as the aspect of *traders' beliefs and behavior* (e.g. [11,13,14]). Nevertheless, few have ever visited the univariate dynamics of trading volume series [43,56], and, to our best knowledge, none has addressed joint dynamics with prices. [2]

As Ying [58] noted almost 40 years ago, stock prices and trading volume are *joint products* from *one single market mechanism*. He argued that "any model of the stock market which separates prices from volume or vice versa will inevitably yield incomplete if not erroneous results" [58, p. 676]. In similar vein, Gallant et al. [25] also asserted that researchers can learn more about the very nature of stock markets by studying the *joint dynamics* of prices in conjunction with volume, instead of focusing on price dynamics alone. As a result, the stock price–volume relation has been an interesting subject in financial economics for many years. [3]

While most of the earlier empirical work focused on the *contemporaneous* relation between trading volume and stock returns, some more recent studies began to address the *dynamic relation*, i.e. *causality*, between daily stock returns and trading volume following the notion of *Granger causality* proposed by Wiener [55] and Granger [27]. In many cases, a bi-directional Granger causality (or a *feedback* relation) was found to exist in the stock price–volume relation, although some other studies could only find evidence of a uni-directional causality: Either returns would *Granger-cause* trading volume, or the opposite situation would prevail [1,37,48,49,51].

As noted by Granger [28], Hsieh [35], and many others, we live in a world which is "almost certainly nonlinear". We cannot be satisfied with only

[1] As Farmer and Lo [22] mentioned, "Evolutionary and ecological models of financial markets is truly a new frontier whose exploration has just begun". By modeling financial markets "as evolving systems of autonomous interacting agents", the agent-based approach in finance, indeed, follows this evolutionary paradigm [54]. Visit *the ACE website* maintained by Leigh Tesfatsion for a comprehensive guide to the field of *ACE*. <*URL*:http://www.econ.iastate.edu/tesfatsi/ace.htm>.

[2] See Chen [9] or LeBaron [42] for reviews of the field of artificial financial markets.

[3] See the survey article by Karpoff [40].