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## Agent-Based Modeling and Investors' Behavior Explanation of Asset Price Dynamics on Artificial Financial Markets

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### Abstract

Standard asset pricing models based on rational expectations and homogeneity have problems explaining the complex and volatile nature of financial markets. The heterogeneity in expectations can lead to market instability and complicate dynamics of prices, which are driven by endogenous market forces. In this sense, we use Agent-based computational approach and more specifically artificial Stock Market modeling to explore the market dynamics from a behavioral perspective. Our aim is to point out that the investors' irrationality explains various numbers of financial anomalies, especially the phenomena that traditional financials models have never been able to explain. We built a virtual financial market that contains three types of investors: fundamentalists, non-fundamentalist and loss adverse investors. Therefore, the difficulty of the prediction is due to several features: the complexity, the non-linearity and the dynamism of the financial market system, as well as the investor psychology. The Artificial Neural Networks learning mechanism take on the role of traders, who from their futures return expectations and place orders based on their expectations. The results of intensive analysis indicate that the existence of agents having heterogeneous beliefs and preferences has provided a better understanding of price dynamics in the financial market.

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## 1. Introduction

Economics and financial theories have been based on rational investors and on market efficiency hypothesis, which posits that market prices fully reflect all available information (Fama, 1970). In traditional models, rational use of information, their decision making is based on utility function with beliefs, calculated via optimal statistical procedures. Thus, the representative investor is an individual who acts as an expected utility maximizer and adheres to the axioms of rational choice theory. These presumptions have clearly played a crucial role in shaping the widely accepted understanding of risk, determinants of asset prices, portfolio management principles, etc. Many financial researchers have examined the core arguments of Efficient Market Hypothesis, Capital Asset Pricing Model, and Anticipation Utility Theory. For instance, Banz (1981) and Bamber (1987) found that fluctuating future stock prices has a “scale effect”. Cross (1973), French (1980), and Gibbons and Hess (1981) also found the “week effect” on the moving trend of stock prices so that investors can gain excess in returns by adapting the reverse operation strategy. Furthermore, Herbert Simon (1991) has emphasized the importance of bounded rationality, taking into account the limited ability of agents to adapt optimally, or even satisfactorily, to complex environments. Paradoxically, it is hardly rational to attempt being perfectly rational. Moreover, a large thread of literature of psychology and behavioral finance instigated by laboratory experiments of Kahneman and Tversky (1973, 1974) and Kahneman (2011) suggest that economic behavior is often better explained by simple heuristic rules and irrational biases rather than by dynamic optimization. According to the prospect theory, the investors’ psychological drives will lead their actual decision-making process to deviate from rationality.

Recently, Chiarella and He (2003) mention a growing dissatisfaction with the representative agent paradigm. Then, LeBaron (2005) and Hommes (2006) state that at the end of the 20th century finance witnessed a revolution and they notice an important paradigm shift from a representative rational agent approach towards a behavioral agent-based approach. More recently, Frijns et al. (2010) mention a demise of the EMH. Behavioral finance provides an alternative theory regarding financial markets. Based on experimental psychology literature, behavioral finance considers that cognitive biases could affect asset prices. In the field of behavioral finance, researchers set psychological biases underlying the behavioral explanations on the observed security price behavior (Kahneman and Tversky, 1979, 1982; Shefrin and Statman, 2000; Barberis and Thaler, 2002; Szyszka, 2008). In fact, individuals are thought to make judgments under uncertainty because limited time and cognitive resources lead them to apply behavioral biases such as herding, loss aversion, anchoring and other behavioral biases by investors’. It seems evident that psychology plays an important role in financial markets and deserves through investigation. The effects of behavioral finance can be viewed as another answer to unrealistic assumptions of the Efficient Market Hypothesis. The confirmation of heterogeneity on the stock market can be founded in empirical research of Vissing-Jorgensen (2003). The author reports that there exists heterogeneity in forecasting future asset prices on the Stock Market: 50% of individual investors consider the stock market to be overvalued, 25% believe that it is fairly valued, about 15% are unsure, and less than 10% believe that is under valued. The complexity of the financial rules governing the stock market and their confrontation with investors’ activities make the interpretation and the explication of observed global behavior very difficult to understand. According to Takahashi and Terano (2003), the investors’ decision making rules which are based on behavioral finance are much more complicated than those adopted in the traditional finance, which makes it difficult to derive asset prices analytically in behavioral finance. In this area of complex system, other recent studies report that complex phenomena emerge from interactions between micro-rules and macro-behavior (Arthur, 1997; Wolfram, 1994).

We cannot understand market outcomes through the eyes of a single representative type of rational agents. In agent-based models, the market is filled with heterogeneous, boundedly rational agents with different expectation and behaviors. This bottom-up method involves large numbers of interacting agents with the “rule of thumb” trading strategies, and the aggregation of simple interactions at the micro level may generate sophisticated structure at the macro level. In the context of financial markets, the micro-rules correspond to investors' behavior and the macro-behavior corresponds to the fluctuation of asset prices. A relatively novel approach for studying the link between individual investors’ behavior and financial market dynamics, based on agent-based methodology, has become known as Artificial Financial Markets. These are often computational models of financial markets, and are usually composed of a number of heterogeneous and bounded rational agents, interacting through some trading mechanism,

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