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An agent-based approach to financial stylized facts

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Abstract

An important challenge of the financial theory in recent years is to construct more sophisticated models which have consistencies with as many financial stylized facts that cannot be explained by traditional models. Recently, psychological studies on decision making under uncertainty which originate in Kahneman and Tversky's research attract a lot of interest as key factors which figure out the financial stylized facts. These psychological results have been applied to the theory of investor's decision making and financial equilibrium modeling. This paper, following these behavioral financial studies, would like to propose an agent-based equilibrium model with prospect theoretical features of investors. Our goal is to point out a possibility that loss-averse feature of investors explains vast number of financial stylized facts and plays a crucial role in price formations of financial markets. Price process which is endogenously generated through our model has consistencies with, not only the equity premium puzzle and the volatility puzzle, but great kurtosis, asymmetry of return distribution, auto-correlation of return volatility, cross-correlation between return volatility and trading volume. Moreover, by using agent-based simulations, the paper also provides a rigorous explanation from the viewpoint of a lack of market liquidity to the size effect, which means that small-sized stocks enjoy excess returns compared to large-sized stocks.

Keywords: Agent-based simulation; Financial stylized facts; Loss-aversion; Prospect theory; Market liquidity

1. Introduction

Statistical features which are commonly observed in return distributions of financial assets are called financial stylized facts. Especially, phenomena that traditional financial models have never been able to explain are often called "anomalies" or "puzzles" and attract special attentions of researchers. An important challenge of the financial theory in recent years is to construct more sophisticated models which have consistencies with as many financial stylized facts that cannot be explained by the traditional models. If the sophisticated model can be constructed, then it means that crucial elements of price formation in financial markets are detected. Hence, to provide models which explain financial stylized facts has been the most

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important subject in modern financial theory. We can easily point out many attempts which extend traditional financial models to this end. For example, Campbell et al. [1] focused on the habit formation in consumer behavior and Epstein and Zin [2] relaxed the time-additive assumption of consumer's utility in traditional models. Recently, psychological studies on decision making under uncertainty which originate in Kahneman and Tversky's research attract a lot of interest as key factors [3]. Benartzi and Thaler [4] and Barberis et al. [5] proposed equilibrium models based on the prospect theory and clarified that the loss-aversion feature was effective to explain some financial stylized facts—the premium puzzle and the volatility puzzle. These behavioral financial models show much promise. However, these models have been able to address only few statistical features among financial stylized facts so far. Needless to say, there remain other robust stylized facts which have practical importance. For example, leptokurtic return distribution and auto-correlation of return volatility are both much important in applications for the derivative pricing problems. As far as we know, there has been no comprehensive study which could explain vast number of stylized facts.

This paper, following the behavioral financial studies, proposes a prospect theoretical equilibrium model where loss-averse investor agents exist. Our goal is to point out a possibility that the loss-averse feature of investors explains vast number of financial stylized facts and plays a crucial role in market price formations. Price process endogenously generated through our model has consistencies with, not only the equity premium puzzle and the volatility puzzle, but the great kurtosis, asymmetry of distribution of returns, auto-correlation of volatility of returns, cross-correlation between volatility of returns and trading volume, and so on. Moreover, the model can examine how these properties are influenced by market liquidity.

Now, comparing our model with the models in Refs. [4,5], which are the best-known models in the behavioral finance area, we can point out the following two new features.

A. Agent-based model. We adopt an agent-based approach since the approach allows us to analyze influences of a lack of market liquidity to price formations. We can also consider heterogeneity of investors instead of assuming a representative symmetric investor.[1]

B. Exponential-type utility. Our model adopts an exponential-type utility function of investors, instead of a power-type utility. In Ref. [4], the representative investor maximizes a loss-averse utility which is formed by a power-type functional form. There are some reasons to adopt the power-type functional form to represent the loss-averse preference; it is empirically more suitable, and the original study of the prospect theory by Kahneman and Tversky [15] has adopted this type of utility. On the other hand, the exponential-type utility function has a good point of easiness of analyzing the equilibrium price. It has solvability of equilibrium price formulas using normally distributed stock together. The solvability of the exponential-type utility allows us to analyze consistencies of price with vast number of financial stylized facts. Since primary interest of this paper is taken to see how the loss-aversion feature and the market liquidity constraints affect endogenous price formations, this paper gives a priority to the easiness of analyzing the equilibrium price that the exponential-type model has.[2]

The results of our analysis are summarized as follows.

(1) In the case where a loss-averse feature of investors is considered, return distributions have the following properties; excess expected return, excess volatility, excess kurtosis, and asymmetry of distribution. These properties are consistent with the observed facts called the equity premium puzzle, the volatility puzzle and the fat-tail.

[1]The agent-based simulation method in financial studies added a new interpretation to phenomena that were not able to be explained by traditional financial models and reexamined validity of assumptions which had been considered to be natural in traditional financial models [6–13]. Now, to locate our analysis in the research context by the agent-based approach, we would like to compare our model to the typical agent-based model which is adopted in Refs. [6,8]. Both models are commonly based on the famous information asymmetric models by Grossman and Stiglitz [14], but our model focuses the loss-averse feature of traders and the market liquidity, instead of the rationality and the learning process which are focused in Refs. [6,8]. In detail, the formation of the expectation concerning a true asset value from obtained information is assumed to be done by the Bayes rule in our model though techniques like the genetic algorithm and the genetic programming are used in these studies.

[2]The exponential-type utility function is typically used in equilibrium models where informational heterogeneous agents exist. For instance, Wang [16,17], and de Fontnouvelle [18] use this type of utility function in asymmetric informational models and try to re-create price processes which are consistent with some of the stylized facts.