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Trading heterogeneity under information uncertainty

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ABSTRACT

Instead of heuristical heterogeneity assumption in the current heterogeneous agent models (HAMs), we derive the trading heterogeneity by introducing information uncertainty about the fundamental value to a HAM. Conditional on their private information about the fundamental value, agents choose different trading strategies when optimizing their expected utilities. This provides a micro-foundation to heterogeneity and switching behavior of agents. We show that the HAM with trading heterogeneity originating from the incomplete information performs equally well, if not better than existing HAMs, in generating bubbles, crashes, and mean-reverting prices. The simulated time series matches with the S&P 500 in terms of power law distribution in returns, volatility clustering and long memory in volatility.

1. Introduction

Heterogeneous agent models (HAMs) are useful in explaining financial market abnormality such as bubbles and crashes (Lux, 1995; Brock and Hommes, 1998; He and Westerhoff, 2005; Huang et al., 2010). They are also powerful in duplicating and analyzing stylized facts of financial data, such as fat tails, volatility clustering and long memory (Alfarano et al., 2008; Huang et al., 2012; He and Li, 2015). More recent evidence suggests that HAMs provide empirical specifications that outperform random walk and many conventional models (de Jong et al., 2010; Chiarella et al., 2012; Lof, 2015). The explanatory power of the existing HAMs mainly comes from exploring market mechanism by focusing more on the interaction among heterogeneous agents, but less so on the role of information friction. In particular, the HAM literature assumes a complete information about the fundamental value of risky assets. It is well recognized that information friction plays a very important role in explaining various puzzles and anomalies in financial markets.[1]

This paper aims to examine the joint role of heterogeneity and information uncertainty in financial markets. It contributes to the HAMs by providing an endogenous mechanism on trading heterogeneity among agents and a micro-foundation to heterogeneity and switching behavior of agents. More explicitly, we consider a HAM in which agents face information

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[1] There is a growing literature that deviates from the standard fundamentalist-chartist setup. For example, Parke and Waters (2007) allow agents to utilize different subsets of the complete information, Kasa et al. (2014) introduce two information sets about the fundamental that are translated into heterogeneous beliefs.

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uncertainty by receiving private noisy signals about the fundamental value of a risky asset when entering the market. Due to the uncertainty about the fundamental value and well-documented price momentum in short-run, agents consider both trading strategies based on the private information and short-run momentum when making their investment decision. Conditional on public information of history price and his private signal, an agent chooses the trading strategy that maximizes his expected utility. This leads to endogenous heterogeneity and switching behavior of agents' choices. We show that the HAM with trading heterogeneity originating from the information uncertainty performs equally well, if not better than existing HAMs, in generating bubbles, crashes, and mean-reverting prices. Numerical analysis shows that the model is able to match with the S&P 500 in terms of power-law distribution in returns, volatility clustering and long memory in volatility.

This paper is closely related to the current HAMs with respect to heterogeneity and switching behavior of agents. However, different from the current HAMs, the heterogeneity of agents in this paper is characterized by agents' choices between two typical trading strategies based on the long-run reversal (to the fundamentals) and short-run momentum (in price trend), the two most prominent financial market anomalies (see, for example, Poterba and Summers, 1988; Jegadeesh and Titman, 1993; Moskowitz et al., 2012). Despite the success HAMs have achieved, many remain skeptical about this approach arguing that they rely on too many heuristic assumptions. Most of the existing HAMs either exogenously specify whether an agent is a fundamentalist or chartist (Frankel and Froot, 1990; Day and Huang, 1990) or assume that agents have a complete information about the fundamental value and switch from one type to another based on some performance measures. In the seminal work of Brock and Hommes (1998), agents switch evolutionarily to the strategy that generates higher past realized profit following a discrete choice probability function. Because of the complete information, agents are able to compare the performance of the two commonly used strategies and switch to better performed strategies. Such an approach is widely applied with different customized switching criteria in subsequent studies.[2] These studies innovatively capture the behavioral aspects of trading and model how agents change their strategy over time, focusing more on the market mechanism of heterogeneous trading on market inefficiency but less (or nor) on the role of information uncertainty. Therefore they are limited to explain why not all agents from the same group switch to better-performing strategies with certainty. If the information is complete, should not all agents cluster to the strategy that is expected to perform better?

This paper aims to provide a micro-foundation on trading heterogeneity and switching behavior of agents' choices by considering information uncertainty and agents' optimal trading decision facing the uncertainty. In this paper, agents are not heterogeneous by nature, experience or randomness. Instead, we assume a continuum of agents who have incomplete information about the fundamental value. Each agent receives a noisy and private signal about the fundamental value when entering the market. Because of the information uncertainty about the fundamental value, agents make their decision by considering trading strategies based on both public and private information.[3] Therefore, agents are allowed to choose either fundamental trading strategy based on the private information or chartist trading strategy based on public information and price trend. Conditional on the public information and his private signal, each agent chooses the strategy that generates a higher expected utility. Due to the information dispersion, agents may choose different trading strategies, generating cross-sectional trading heterogeneity among agents. Instead of switching exogenously based on certain probability, agents switch their choices on the trading strategies endogenously based on their information and the optimal trading. As market prices and agents' private information change, the market fractions of agents choosing particular strategies vary over time. As a result, both cross-sectional and time-varying trading heterogeneity arise.

Representing enumerable strategies with fundamental and chartist trading strategies is on the one hand motivated by the survey finding (Allen and Taylor, 1990) that most investors, especially institutional investors, conduct both fundamental and technical analysis. On the other hand, this is also motivated by the long-run mean-reversal and short-run momentum in prices, the two market anomalies observed widely across various financial markets. It also follows from the conventional setup in HAMs. Even though agents are well-informed about the fundamental value, because of the information uncertainty about the fundamental value, an agent may choose chartist strategy when it is expected to generate higher expected utility conditional on public information and his private signal. In particular, when mispricing based on the private information is expected to be small, a fundamental trading strategy may lead to a lower expected utility, while a short-run momentum strategy may lead to a higher expected utility, which motivates agents to choose chartist strategy. Among various trading strategies based on the public information, we choose momentum strategy which is widely used in the HAMs and well supported by empirical evidence on short-run momentum. As a result, the fractions of agents who choose fundamental and momentum strategies are uniquely determined by the distribution of the private signals and the past asset prices.

In our model, the market fraction of agents who choose the fundamental trading strategy generally increases with the degree of asset mispricing, but declines with the market power of agents who choose momentum strategy. Here the degree of mispricing is measured by the absolute difference between market price and the expected fundamental value, while the market power is measured by the absolute difference between market price and a reference price or price trend. As the

[2] See for example, de Jong et al. (2010), and Jongen et al. (2012). For other switching mechanism, see Chiarella et al. (2012) that models the fraction of fundamentalists as a Markov process conditional on some unobserved market conditions, i.e. booms and burst states; Lof (2012) that updates the fractions of fundamentalists and chartists according to a discrete function of the real business cycles.

[3] With complete information assumption in the current HAMs, agents are able to compare the performance of different trading strategies. However, facing the information uncertainty, it makes agents more difficult, if not impossible, to compare the performance of these two strategies and choose the better performed one.