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Market entry waves and volatility outbursts in stock markets☆

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ABSTRACT

We develop a simple agent-based financial market model in which speculators' market entry decisions are subject to herding behavior and market risk. In addition, speculators' orders depend on price trends, market misalignments and fundamental news. Using a mix of analytical and numerical tools, we show that a herding-induced market entry wave may amplify excess demand, triggering lasting volatility outbursts. Eventually, however, higher stock market risk reduces stock market participation and volatility decreases again. Simulations furthermore reveal that our approach is also able to produce bubbles and crashes, excess volatility, fat-tailed return distributions and serially uncorrelated price changes. Moreover, trading volume is persistent and correlated with volatility.

1. Introduction

The goal of our paper is to develop a simple agent-based financial market model to explain a number of important stylized facts of stock markets. In particular, we analytically and numerically demonstrate that speculators' market entry and exit behavior may give rise to volatility clustering. Our model's key features and its main implications may be summarized as follows. We assume that there is a market maker who adjusts stock prices with respect to speculators' orders, which, in turn, use technical and fundamental trading rules to determine their trading behavior. Speculators' market entry decisions depend on two socio-economic principles. First, speculators are subject to herding behavior and increasingly enter the stock market as the number of active speculators increases. Second, speculators react to stock market risk. The higher the past volatility of the stock market, the lower the probability that a speculator will enter the stock market. As it turns out, the stock market is relatively stable if the number of active speculators is low. Since stock market risk is then perceived as negligible, more and more speculators become active. Consequently, excess demand increases, the market maker adjusts stock prices more strongly and volatility picks up. Due to the increase in stock market risk, stock market participation eventually decreases again. Confronted with a lower excess demand, the market maker needs to adjust stock prices less strongly.

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We also show that the repeated inflow and outflow of speculators along with their heterogeneous trading behavior may produce bubbles and crashes, excess volatility, serially uncorrelated returns and a fat-tailed return distribution. Moreover, trading volume displays significant memory effects and is strongly correlated with volatility. Keeping track of the individual speculators' wealth dynamics reveals that heterogeneity among speculators may be a persistent phenomenon of financial markets, i.e. neither do a few speculators accumulate all the wealth and dominate the market nor does a substantial fraction of speculators go bankrupt and vanish from the market.

Our paper adds to the burgeoning stream of literature on agent-based financial market models (see Chiarella et al., 2009a; Hommes and Wagener, 2009; Lux, 2009 for surveys). Within these models, speculators apply technical and fundamental trading rules to determine their orders. Technical trading rules (Murphy, 1999) are usually based on trend extrapolation and tend to destabilize the dynamics of financial markets. In contrast, fundamental trading rules (Graham and Dodd, 1951) bet on mean reversion, exercising a stabilizing impact on the dynamics of financial markets. Models by Day and Huang (1990), De Grauwe et al. (1993), Brock and Hommes (1998), LeBaron et al. (1999), Farmer and Joshi (2002), Chiarella et al. (2007), Franke and Westerhoff (2012) and Jacob Leal and Napoletano (2017), for example, show that (non-linear) interactions between speculators relying on technical and fundamental trading rules can produce dynamics which resembles the dynamics of actual financial markets quite closely. Without question, this line of research helps us to improve our understanding of the functioning of financial markets. For instance, agent-based financial market models reveal that a bubble may emerge if speculators forcefully rely on technical analysis while a crash can be set in motion if speculators put more weight on fundamental analysis. Such a time-varying impact of technical and fundamental trading rules can also produce volatility clustering. Financial markets tend to be relatively stable when speculators prefer fundamental analysis but turn wilder when speculators opt for technical analysis.

Herding behavior plays a prominent role in a number of agent-based financial market models. In Alfarano and Lux (2007); Kirman (1993); Lux and Marchesi (1999), speculators' herding behavior influences whether they choose technical or fundamental trading rules to determine their orders. Cont and Bouchaud (2000) and Stauffer et al. (1999) assume that speculators' herding behavior influences whether they are optimistic or pessimistic. Bischi et al. (2006) show that complex asset price dynamics may emerge if speculators mimic the buying and selling behavior of other speculators. LeBaron and Yamamoto (2008) study imitation behavior which results from social learning and show that it may be responsible for long memory effects in trading volume and volatility. Tedeschi et al. (2012) develop a model in which speculators imitate the behavior of more successful speculators. In Schmitt and Westerhoff (2017), speculators' herding behavior may lead to changes in the heterogeneity of trading rules applied. Compared to these models, we assume in our paper that speculators' herding behavior affects their stock market participation.

In fact, empirical evidence suggests that stock market participation changes over time and is influenced by social interactions. Most importantly for our approach, Hong et al. (2004, 2005), Brown et al. (2008) and Shiller (2015) report that households and professional investors regard a stock market as increasingly attractive the more of their peers participate in it. Surprisingly, there are only a few agent-based models which explicitly study speculators' market entry and exit behavior. Alfi et al. (2009b, 2009c, 2009a) show that agent-based models with a fixed number of speculators may lose their ability to produce realistic dynamics if the number of speculators is set either too high or too low. Against this background, they endogenize the number of speculators and explore under which conditions the model dynamics may self-organize such that the number of active speculators approaches a level which generates realistic dynamics. Iori (1999, 2000) develops a more involved agent-based simulation framework with heterogeneous interacting agents. Due to trade frictions, such as trading costs or information processing constraints, speculators may become inactive. However, communication and imitation among speculators may lead to a spontaneous spark in stock market participation and elevate price fluctuations. To study the effects of transaction taxes, Westerhoff and Dieci (2006) develop a model in which speculators have the choice between technical trading, fundamental trading and being inactive. Speculators' choices depend on the past profitability of these alternatives. Schmitt and Westerhoff (2016) show that although speculators' inflow and outflow may create bubbles and crashes, their market entry and exit behavior is not subject to herding effects.

Our approach differs to these contributions in several dimensions. One advantage of our model is that its deterministic skeleton allows us to derive a number of analytical insights which make the model's functioning and the origin of volatility clustering rather transparent. For instance, our model possesses a steady state in which prices reflect their fundamental values and in which all speculators are active. We analytically show that this steady state becomes unstable (via a Neimark–Sacker bifurcation) if speculators strongly extrapolate past price trends. Simulations reveal that the dynamics we then observe are characterized by alternating periods of high volatility, pushing destabilizing speculators out of the stock market, and periods of low volatility, attracting destabilizing speculators to the stock market. The same forces are at work in a stochastic version of our model which is able to mimic a number of important time series properties of stock markets. It is important to note that our results are not driven by speculators who constantly lose money or by speculators who become very rich.

The rest of our paper is organized as follows. In Section 2, we present our simple agent-based financial market model. In Section 3, we study the properties of the model's deterministic skeleton. In Section 4, we illustrate that the model's stochastic version is able to replicate a number of important stylized facts of stock markets. In Section 5, we conclude our paper and point out some avenues for future research.