Journal of Banking & Finance 43 (2014) 150–159

Contents lists available at ScienceDirect

Journal of Banking & Finance

journal homepage: www.elsevier.com/locate/jbf

Time-varying, heterogeneous risk aversion and dynamics of asset prices among boundedly rational agents

Beum-Jo Park *

Department of Economics, Dankook University, 44-1 Jukjeon-dong, Yongin-si, Gyeonggi-do 448-701, South Korea

ARTICLE INFO

Article history:
Received 2 December 2013
Accepted 11 March 2014
Available online 20 March 2014

JEL classification:
G02
G10
C10

Keywords:
Boundedly rational agents
Time-varying and heterogeneous risk aversion
Herding
Adaptive beliefs system
Asset price dynamics
Excess volatility
Asymmetry in volatility

ABSTRACT

Besides the heterogeneity of agents' beliefs, we perceive that, contrary to the constant short-term risk attitude of fundamentalists, the risk attitude for chartists varies over time due to psychological factors such as prospect theory's reflection effect, which refers to the reversing of risk aversion/risk loving in the case of gains/losses. Thus, this paper assumes that complicated dynamics in recent asset markets are attributed to the significant effects of time-varying and heterogeneous risk attitudes as well as agents' herd behavior, and generalizes an adaptive beliefs system in order to characterize them. This paper also analyzes the existence of stable steady states of the generalized adaptive beliefs system, providing a new psychological insight into excessive and asymmetric volatility. Given the dynamic system, numerical simulations find that, when the chartists are less risk averse than the fundamentalists and their herding propensity increases, time variation in risk attitudes gives rise to large amplitude changes in proportion to agent groups and expand price fluctuations through chaotic dynamics. Along these lines, this paper highlights that psychological factors serve as decisive source of asymmetry in volatility as well as excess volatility, which are observed in the return data.

1. Introduction

A behavioral and agent-based approach has been the subject of most active bodies of literature in economics and finance (Zeeman, 1974; Frankel and Froot, 1990; Sargent, 1993; Brock and Hommes, 1997, 1998; Chiarella and He, 2003; LeBaron, 2005; Park, 2011, among others), in that a number of psychological and empirical studies have cast doubt on the traditional approaches based on perfectly rational and representative agents. In particular, after the global financial crisis of 2007 substantially complicated dynamics in asset markets have caused us to shed new light on the role of heterogeneous agents that are closely linked to trade among agents as well as to volatility clustering. Significantly, in spite of the validity of the models of asset price dynamics with boundedly rational and heterogeneous agents, the models may not be sufficient to deal with excess volatility in recent asset markets or asymmetry in return volatility (e.g., Black, 1976; Nelson, 1991; Park, 2002, 2007) due to unrealistic assumptions of constant and homogeneous risk aversion.

As emphasized by Kahneman and Tversky (1979), attitudes toward risk tend to be sensitive to psychological factors such as prospect theory's reflection effect, which refers to the reversing of risk aversion/risk loving in the case of gains/losses.[1] This implies that sign changes of the expected outcomes, measured as expectations of excess returns in this paper, result in frequent changes of attitudes toward risk, engendering risk aversion to be time-varying even in the short run because agents continually adapt information on realized returns. In addition, some of the preceding literature confirms that attitudes toward risk are different in terms of the types of agents (Miller, 1977; Poterba and Summers, 1988; DeLong et al., 1990; Campbell and Kyle, 1993; Chiarella and He, 2002b, 2003, among others).

Motivated by the above evidence on the restrictions of risk aversion assumptions, we propose a more feasible asset pricing

[1] It is well-known that in the long run risk aversion may be changed over time by some principal factors such as a structural change in preference or difference habits (subsistence levels or consumption commitments) (e.g., Abel, 1990; Brunnermeier and Nagel, 2008); however, in the short run, the principal factors should no longer be effective. By contrast, it is feasible that even in the short run, psychological factors can frequently change the risk attitudes of chartists to noisy traders (e.g., Barberis et al., 2001; Guiso et al., 2013).

* Tel.: +82 31 8005 3385.
E-mail address: bjpark@dankook.ac.kr

http://dx.doi.org/10.1016/j.jbankfin.2014.03.009
0378-4266/

model by taking into account the heterogeneous and boundedly rational agents that differs from previous models. We conduct this proposal by incorporating some key features, which have their origins in psychological factors, in an adaptive beliefs system of Brock and Hommes (1997, 1998): in particular, (i) time-varying risk aversion, (ii) heterogeneous risk attitudes, (iii) herding tendency. Thus, we focus on the intuition that, in addition to the heterogeneity of beliefs, time-varying and heterogeneous risk aversion plays an important role in the interaction between the two agent types distinguished, fundamentalists and chartists, and in the formation of asset prices, leading to market instability; moreover, its influence on the market is closely related to herd behavior.

Theoretically, this paper analyzes the existence of stable steady states of the generalized adaptive beliefs system, which aims at considering not only volatility clustering, but excessive and asymmetric volatility. That is, the generalized adaptive beliefs system exhibits the coexistence of attractors generating volatility clustering. Further, it amplifies the deviations of prices from fundamental benchmarks (i.e., excessive volatility) due to chaotic dynamics whenever the chartists are less risk averse compared to the fundamentalists, according to prospect theory's reflection effect; moreover, their herding tendency increases. In addition, it is expected that in the case of losses an increase in volatility is bigger than in the case of gains, leading to asymmetry in return volatility.[2] This is our fascinating insight. In other words, the heterogeneous and boundedly rational agents associated with psychological factors are likely to play a decisive role in asymmetric volatility that is a prevailing property in financial markets.

In this context, to investigate the effect of both time-varying and heterogeneous risk aversion and herd behavior on asset price dynamics, we implement numerical simulations, which provide some valuable findings. First, when chartists are less risk averse than the fundamentalists, the time-varying and heterogeneous risk aversion gives rise to large amplitude changes in proportion to the agent groups, and also makes the asset price dynamics unstable through bifurcation. Second, as the herding of chartists as trend chasers increases, the destabilizing force tends to be considerably magnified by chaotic dynamics. Third, our model accounting for psychological factors generates more realistic outcomes in terms of the stylized facts of asset markets, e.g. asymmetry in returns, fat tails and volatility clustering. Note that in order to demonstrate the resemblance on the dynamics of our model to the real ones, we consider daily returns for the NASDAQ composite index as a benchmark for comparison.

The rest of this paper proceeds as follows. Section 2 generalizes the adaptive beliefs system of Brock and Hommes (1997, 1998) in order to account for time-varying and heterogeneous risk aversion. Section 3 verifies the existence of stable steady states of the generalized model. Section 4 implements numerical simulations in order to examine the dynamics of the generalized model and provide some evidence for the substantial effect of time-varying risk aversion and herding on price fluctuations. It is corroborated that the basic intuition of psychological influence on asset price dynamics is valid. Section 5 concludes with brief suggestions for future research. Finally, all proofs are included in Appendix A.

2. Theoretical framework

2.1. A simple heterogeneous asset pricing model

To examine the effect of time-varying and heterogeneous risk aversion on the dynamics of asset prices, we devote to an extension of the asset pricing model proposed by Brock and Hommes (1997, 1998). Following their framework, consider an asset pricing model with one risky asset, whose price (ex-dividend) per share at time t is denoted by p_t, and one risk-free asset which is assumed to be perfectly elastically supplied at a gross return $R > 1$. Let y_t be the stochastic dividend process of the risky asset. Then the dynamics of wealth is given by

$$W_{t+1} = RW_t + (p_{t+1} + y_{t+1} - Rp_t)z_t \tag{1}$$

where W_t is the wealth at time t and z_t is the number of shares of the risky asset purchased at time t. The price p_t is formed by using information available up to time $(t-1)$. The information set at time t is denoted by $\Phi_t = \{p_t, p_{t-1}, p_{t-2}, \cdots; y_t, y_{t-1}, y_{t-2}, \cdots\}$ Let E_t and V_t denote the conditional expectation and variance, respectively, based on Φ_t, and E_{ht}, V_{ht} denote the 'beliefs' of type h agent regarding the conditional expectation and conditional variance. Denote R_{t+1} as the excess return at time $t+1$, $R_{t+1} = p_{t+1} + y_{t+1} - Rp_t$. Then, we obtain

$$E_{ht}(W_{t+1}) = RW_t + E_{ht}(R_{t+1})z_t \tag{2}$$

$$V_{ht}(W_{t+1}) = z_t^2 V_{ht}(R_{t+1}) \tag{3}$$

It is assumed that each agent has a constant absolute risk aversion (CARA) utility function: $U(W_t) = -\exp(-\alpha_h W_t)$, where $\alpha_h > 0$ is the risk aversion coefficient that allows for a difference according to the agent's type. To reflect the reality of dynamics of asset prices, it should be assumed later that the risk aversion coefficient varies over time even in the short run due to psychological factors. By maximizing the expected utility of wealth, h type agent obtains the optimal demand on the risky asset:

$$z_{ht} = \frac{E_{ht}(R_{t+1})}{\alpha_h V_{ht}(R_{t+1})} \tag{4}$$

Let z_{St} denote the supply of risky shares and n_{ht} the fraction of agents of type h at time t. The equilibrium of demand and supply implies, $\sum_h n_{ht} z_{ht} = z_{St}$. Following Brock and Hommes (1998), Hommes (2001) and Chiarella and He (2002a, 2002b), we assume a zero supply of outside risky shares, namely $z_{St} = 0$, without loss of generality. The market clearing price of the risky asset is determined by $Rp_t = \sum_h n_{ht} E_{ht}(p_{t+1} + y_{t+1})$. Since, in equilibrium, the expectation of the price is equivalent to the fundamental solution, in the case of only one type of agent the fundamental price p_t^* is derived from the equation:

$$Rp_t^* = E_t(p_{t+1}^* + y_{t+1}) \tag{5}$$

where E_t is the expectation conditional on the information set Φ_t. Under the assumption of independently and identically distributed (i.i.d) dividends with mean $\bar{y}$, i.e., $E_t(y_{t+1}) = \bar{y}$, there is only one solution $p_t^* = \bar{p} = \bar{y}/(R-1)$, satisfying the 'no bubble' condition $\lim_{t\to\infty} E(p_t)/R^t = 0$.

Assuming the differences in agents' beliefs, we consider the popular fundamentalist/chartist model. More specifically, all agents are assumed to be grouped as either fundamentalists (type F) or chartists (type C). We define the deviation of the actual price p_t from the fundamental price p_t^* as $x_t = p_t - p_t^*$. Heterogeneous beliefs of h type agents on the mean and variance are assumed to be of the form

$$E_{ht}(p_{t+1} + y_{t+1}) = E_t(p_{t+1}^* + y_{t+1}) + f_h(x_{t-1}, \cdots, x_{t-L}) \tag{6}$$

$$V_{ht}(p_{t+1} + y_{t+1}) = V_t(p_{t+1}^* + y_{t+1}) + g_h(x_{t-1}, \cdots, x_{t-L}) \tag{7}$$

where f_h and g_h are some deterministic function which can differ across agent types h and L is a positive integer. As in Brock and Hommes (1998), Eq. (6) assumes that the prediction of each group of agents as to the mean consists of two parts, a fundamental part

[2] Some authors (Hibbert et al., 2008; Park, 2011, among others) postulate that the asymmetry in return volatility can be attributed to the behavior or psychology of agents in financial markets.