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Decision Support

A mispricing model of stocks under asymmetric information

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ABSTRACT

We extend the theory of asymmetric information in mispricing models for stocks following geometric Brownian motion to constant relative risk averse investors. Mispricing follows a continuous mean-reverting Ornstein–Uhlenbeck process. Optimal portfolios and maximum expected log-linear utilities from terminal wealth for informed and uninformed investors are derived. We obtain analogous but more general results which nests those of Guasoni (2006) as a special case of the relative risk aversion approaching one.

1. Introduction

Asset pricing and portfolio selection problems are fundamental issues in finance and economics. In an efficient market, it is assumed that asset prices always fully reflect available information. Thus, it is natural to use random walk or geometric Brownian motion models in asset pricing. All the investors in such an efficient market have the same amount of information to utilize for portfolio selection. In this framework, Markowitz (1952) proposed the celebrated mean-variance portfolio selection model over single-period, which laid the foundation of modern portfolio theory. This work has been generalized in many ways. First, multi-period portfolio selection has been extensively studied by many authors such as Mossin (1968), Samuelson (1969), Fama (1970a), Hakansson (1971), Elton and Gruber (1974), Francis (1976), Ostermark (1991), Li and Ng (2000), Soyer and Tanyeri (2006), Dokuchasev (2007), Celikyurt and Ozekici (2007), Canakoglu and Ozekici (2010) and references therein. Second, continuous-time portfolio selection problems have been discussed in Merton (1969, 1971, 1972), Pliska (1986), Karatzas et al. (1987), Cox and Huang (1989), Davis and Norman (1990), Duffie and Richardson (1991), Zhou and Li (2000). Third, the constrained portfolio selection problems in both discrete and continuous time have been studied by many authors such as Paxson (1990), Cvitanic and Karatzas (1992), Mansini and Speranza (1999), Kellerer et al. (2000), Carassus et al. (2001), Li et al. (2002), Crama and Schyns (2003), Corazza and Favaretto (2007), Lin and Liu (2008), Fu et al. (2010) and references therein. We should also mention other extensions of the Markowitz model, for example, mean-absolute deviation model (Konno and Yamazaki, 1991; Simaan, 1997; Yu et al., 2010), mean-VaR model (Benati and Rizzi, 2007; Huang et al., 2010), and minimax type model (Young, 1998; Ghezzi, 1999; Deng et al., 2005).

However, empirical studies showed that there are many market anomalies including excess volatility, investor overreaction and under-reaction, namely the market is inefficient. This suggests that we need to consider the asset pricing and portfolio selection in the inefficient market. In this framework, it is assumed that the asset has both the fundamental value and market value. The difference between the market value and the fundamental value represents the current mispricing of the asset. We consider two types of investors: informed investors, who observe both fundamental and market values, and uninformed investors, who only observe market values. Their information is modeled by two different filtrations – the less informed investor has a sigma – field $\mathcal{F}^0$, corresponding to the natural evolution of the market, while the better informed investor has the larger filtration $\mathcal{F}^1$, which contains the information of the uninformed investor. Understanding the link between asset mispricing and asymmetric information is a topic of ongoing interest in the finance literature.

Mispricing models for stocks under asymmetric information were first studied in Shiller (1981) and Summers (1986) in a purely deterministic setting. This was extended by Guasoni (2006) to the purely continuous random environment, where stock prices follow geometric Brownian motion (GBM) and utility is logarithmic.

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Fads/mispricing follow a continuous mean-reverting Ornstein–Uhlenbeck (O–U) process. There are two investors trading in the market – the uninformed and informed investors. Guasoni (2006) gives optimal portfolios and maximum expected logarithmic utilities, including asymptotic utilities for both uninformed and informed investors. He also gives the excess asymptotic utility of the informed investor.

Buckley (2009) extends this theory to Lévy markets, where stock prices jump. Utility functions are assumed to be logarithmic. Jumps are modeled by pure jump Lévy processes, while the mispricing is represented by a purely continuous mean-reverting O–U process driven by a standard Brownian motion, as in Guasoni (2006). The author obtains optimal portfolios and maximum expected logarithmic utilities for both the informed and uninformed investors, including asymptotic excess utility which is analogous to the result obtained in Guasoni (2006) in the purely continuous case. The random portfolios of the investors are linked to the symmetric, purely deterministic optimal portfolios of Lévy diffusion markets having deterministic market coefficients.

In this paper, we generalize the theory of mispricing models of stocks under asymmetric information, where investors preference are from the power utility family. We allow the stock price dynamic to move continuously as geometric Brownian motion, while the mispricing process remains as a continuous mean-reverting Ornstein–Uhlenbeck process. We obtain analogous but more general results which includes those of Guasoni (2006) as a special case of the risk aversion approaching one.

The practical economic and operational implications of this paper are that when asymmetric information, risk aversion and mispricing exist in a stock market that evolves continuously, both informed and uninformed investors will maximize their expected utility from terminal wealth by holding portfolios that contain excess stock holdings which depend not only on the levels of information asymmetry but also on the relative risk aversion and the degree of mispricing. The excess stock holding may be positive or negative but at all times it is expected to be zero. Consequently, the portfolio of each investor will be stochastic, but it is expected to be a deterministic portfolio as in a purely symmetric market, such as Merton's optimal portfolio. Moreover, our results show that, not withstanding the existence of mispricing and risk aversion, it pays off to be more informed in the long run.

The rest of the paper is organized as follows: Section 2 gives a brief literature review and the model is introduced in Section 3. Filtrations are defined in Section 4, while price dynamics for both informed and uninformed investors are introduced in Section 5. Section 6 introduces CRRA (Constant Relative Risk Aversion) utility functions of the power class, while Section 7 presents portfolio and wealth processes. The main result is presented in Sections 8. We obtain optimal portfolios and log-linear maximum expected utilities for both the informed and uninformed investors, including asymptotic excess utility for the informed investor. Section 9 concludes.

2. Literature review

2.1. Continuous-time mispricing models

In this section, we give a brief literature review of asymmetric information in mispricing models in a purely continuous random market – that is, in a market where stock prices and mispricing move continuously, without jumping. Discrete-time fads/mispricing models were first introduced in Shiller (1981) and LeRoy and Porter (1981) as plausible alternatives to the efficient market/constant expected returns/discount rate assumption (cf Fama, 1970b).

Studies by Flavin (1983), Kleidon (1986), and March and Merton (1986), criticize these findings based on the statistical validity of these volatility tests. However, other studies confirm the earlier findings of the variance bounds tests of Shiller (1981) and LeRoy and Porter (1981). For example, West (1988) develops a stock market volatility test that overcame these criticisms. West's inequality test proves that, if discount rates are constant, the variance of the change in the expected present discounted value of future dividends is larger when less information is used. He also finds that stock prices are too volatile to be the expected present discounted value of dividends when the discount rate is constant.

Campbell and Shiller (1987) find that when dividends and prices are non-stationary, they are co-integrated under the dividend discounted model, that is, there is a linear combination of the two that is stationary. Using cointegration and the VAR (vector autoregressive) framework, they also confirm the findings of Shiller (1981).

Given the failure of the discounted dividend model to explain stock price variations, some researchers introduced behavioral finance models as possible alternatives. Summers (1986) and Cutler et al. (1990) introduce irrational/noise traders, and the slow response to changes in fundamentals. De Long et al. (1990), suggest that noise trading in the market can increase price volatility, which impacts the risk of investing in the stock market and the risk premium. Campbell and Kyle (1993) also suggest that the existence of noise trading in the market can help explain the high volatility of stock prices. Daniel et al. (1998) develop a theory of mispricing based on investor overconfidence resulting from biased self-attribution of investment outcomes.

Barberis et al. (1998) provide an explanation for over and under-reactions based on a learning model in which actual earnings follow a random walk but individuals believe that earnings follow a steady growth trend, or are mean reverting. Odean (1998) provides a model where overconfident traders can cause markets to under-react to the information of rational traders, leading to positive serially correlated returns.

Wang (1993) gives a model of intertemporal/continuous-time asset pricing under asymmetric information. In his paper, investors have different information concerning the future growth rate of dividends, which satisfies a mean-reverting Ornstein–Uhlenbeck process. Informed investors know the future dividend growth rate, while uninformed investors do not. All investors observe current dividend payments and stock prices. The growth rate of dividends determines the rate of appreciation of stock prices, and stock price changes provide signals about the future growth of dividends. Uninformed investors rationally extract information about the economy from prices, as well as dividends. Wang (1993) shows that asymmetry among investors can increase price volatility and negative autocorrelation in returns; that is, there is mean-reverting behavior of stock prices. Thus, imperfect information of some investors can cause stock prices to be more volatile than in the symmetric case, when all investors are perfectly informed.

Brunnermeier (2001) presents an extensive review of asset pricing models under asymmetric information mainly in the discrete setting. He shows how information affects trading activity, and that expected returns depend on the information set or filtration of the investor. These models show that past prices still carry valuable information, which can be exploited using technical/chart analysis, which uses part or all of past prices to predict future prices.

Guasoni (2006) extends the model of Summers (1986) to the purely continuous random setting. He develops models of stock price evolution for two disjoint classes of investors; the informed and uninformed investors. The informed investor, indexed by $i = 1$, observes both the fundamental and market values of the stock, while the so-called uninformed investor, indexed by $i = 0$, observes market prices only. Both investors have filtrations or information banks $\mathcal{F}^i,\ i \in \{0, 1\}$ with $\mathcal{F}^0 \subset \mathcal{F}^1 \subset \mathcal{F}$, where $\mathcal{F}$ is a