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Contents lists available at ScienceDirect

Journal of Financial Markets

journal homepage: www.elsevier.com/locate/finmarLimited participation under ambiguity of correlation [☆]Helen Hui Huang ^a, Shunming Zhang ^{b,*}, Wei Zhu ^c^a Faculty of Business Administration, University of Regina, Regina, SK, Canada S4S 0A2^b China Financial Policy Research Center, School of Finance, Renmin University of China, Beijing 100872, PR China^c Department of Statistics and Actuarial Science, University of Hong Kong, Pokfulam, Hong Kong

ARTICLE INFO

Article history:

Received 28 October 2015

Received in revised form

7 October 2016

Accepted 20 October 2016

JEL classification:

G02

G11

D80

D81

Keywords:

Ambiguity aversion

Correlation ambiguity

General equilibrium

Limited participation

Flight to quality

ABSTRACT

In this paper, we investigate the implications of correlation ambiguity for investor behaviors and asset prices. In our model, individuals' decision making incorporates both risk and ambiguity, and we demonstrate that limited participation arises from the rational decision by naïve investors to avoid correlation ambiguity. In equilibrium, the asset with lower quality generates positive excess returns. Comparative static analysis of the equilibrium result suggests that changes in the fraction of naïve investors and ambiguity level can alter equilibrium types and flight to quality phenomenon is observed. However, their impacts on asset prices are non-monotonic.

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1. Introduction

Ambiguity aversion arises when individuals incorporate both risk and ambiguity in their decision making. Knight (1921) makes a distinction between known odds (risk) and unknown odds (ambiguity). Gilboa and Schmeidler (1989) and Schmeidler (1989) conduct axiomatic analyses for decision making with ambiguity aversion. So far, ambiguity has been widely applied to many kinds of asset pricing models (e.g., Chen and Epstein, 2002; Illeditsch, 2009; Epstein and Ji, 2012, 2013) and provides explanatory power for some behavioral anomalies in financial markets, such as limited participation (e.g., Cao et al., 2005; Easley and O'Hara, 2009), negative skewness in returns (Epstein and Schneider, 2008), market microstructure (Easley and O'Hara, 2010), and so on. However, researchers focus more on ambiguity of mean and variance, and ignore the ambiguity of correlation, an equally important parameter of the economy. Correlation is ubiquitous in financial markets and plays a central role in portfolio choices (Markowitz, 1952; Samuelson, 1969) and asset pricing models (e.g.,

[☆] This work is supported by the Social Sciences and Humanities Research Council of Canada (SSHRC) Insight Development Grant (# 430-2012-0698), the National Natural Science Foundation of China (NSFC Grant Numbers: 71273271 and 71573220), the Major Basic Research Plan of Renmin University of China (Grant Number: 14XNL001), and the KPMG Research Scholar Award (Faculty of Business Administration, University of Regina). All errors are our own.

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Sharpe, 1964; Litner, 1965; Duffie and Singleton, 2003). Thus, it is natural and of importance for us to study the ambiguity of correlation.

In this paper, we focus on the implications of correlation ambiguity for three reasons. First, we think that it is natural and intuitive for naïve investors to perceive ambiguity in the correlation between assets rather than in mean or variance of individual assets. Unlike the expected payoff and volatility, correlation measures between the prices of different assets are rarely disclosed. Hence, it is rather difficult for non-professional investors to form up the precise perception of connections among assets. That is, by observing the data of two assets, one can hardly tell whether they are more likely to be positively or negatively correlated, let alone estimating the true value of the parameter. Second, as with all other types of ambiguity, the introduction of correlation ambiguity appeals to the robustness of decision making. Although there are many statistical methods for professionals to estimate correlation coefficients, a single estimate is far away reliable for future investment decisions, especially when the economic environment shifts rapidly. Thus it is a wiser choice for professionals to make investment decisions with references to more than one prior, instead of acting on a single prior. Third, theoretically speaking, as it turns out, ambiguity of correlation can indeed generate interesting implications for the financial markets, which we elaborate later.

The economy we investigate in this paper is a natural extension of the models in Cao et al. (2005) and Easley and O'Hara (2009). The economy has one risk-free asset and two risky assets. The risky assets have normally distributed payoffs. Disparate from Easley and O'Hara (2009) where ambiguity lies in the expected payoffs and variances of risky assets, heterogeneous beliefs of the correlation coefficient between two risky assets are assumed among investors, while they have common knowledge of the means and variances of those two assets.¹ Sophisticated investors are standard expected utility maximizing agents and have rational expectations of the parameters of the economy. Naïve investors are ambiguity-averse agents who have rational expectations on the marginal distributions of assets but perceive the correlation coefficient of the assets as ambiguous. The decision-making of these naïve investors is described by the maxmin utility model proposed by Gilboa and Schmeidler (1989).

As compared to Easley and O'Hara (2009), the demand function of naïve investors shows three new and interesting features. First, nonparticipating decisions on risky assets arise from the rational decisions by naïve investors to avoid ambiguity. The decisions to hold incomplete portfolios are determined by the set of correlation coefficients that are considered by naïve investors. Second, the demand functions of naïve investors are continuous and have kinks at certain prices. Third, naïve investors trade in the same direction as sophisticated investors. That is, when naïve investors hold a non-zero position on a risky asset, the sophisticated investors' position is in the same direction. Under this setup, we show that naïve investors' demand function intersects with the demand of sophisticated investors, which implies that naïve investors might hold larger positions than sophisticated investors. This result differs from the result of Easley and O'Hara (2009).

In equilibrium, the product of the standard deviation and per capita endowment acts as a measure of quality. The unique equilibrium prevailing in the economy has three alternative types. When the quality of an asset is comparatively small (the ratio against the other asset's quality smaller than a threshold that is determined by the true value of the correlation coefficient and degree of ambiguity), nonparticipation on this asset will occur as an endogenous result. Note that the limited participation result in our paper is different from that in Easley and O'Hara (2009) in that in our result non-participation on both assets cannot happen. We also show that under equilibrium, naïve investors could trade more intensively than sophisticated investors in one of the risky assets.

Further analysis suggests another two key implications of correlation ambiguity for asset prices and limited market participation. First, the capital asset pricing model (CAPM) analysis reveals that the asset with lower quality generates positive excess returns, no matter whether it is held by naïve investors. Second, the flight to quality phenomenon will be observed when parameters in the economy change. Specifically, when the fraction of naïve investors drops or the level of ambiguity increases, the prevailing participating equilibrium might be altered to a non-participating one, and naïve use double dot accent over "i" investors will only hold the assets with higher quality. However, the influence of parameter changes on asset prices are non-monotonic, which suggests that policies pertaining to ambiguity can have profound impacts on asset prices and social welfare. In addition, increasing the market participation of one risky asset will not cause the nonparticipation of the other asset.

Our model is closely related to a large and growing literature on the behavioral phenomena and asset pricing anomalies in the financial markets, in the presence of ambiguity aversion. Cao et al. (2005) and Easley and O'Hara (2009) use the maxmin expected utility model to demonstrate limited participation as a result of ambiguity about the asset's expected payoff and variance. Condie and Ganguli (2011) demonstrate the existence and robustness of partially revealing rational expectations equilibria in economies with ambiguity-averse preferences. Easley et al. (2014) investigate the effect of ambiguity in hedge fund strategies on asset prices and aggregate welfare, thus providing a profound interpretation of disclosure policies implemented upon hedge funds.

Our paper is different and thus complements the above papers in two ways. First, our source of ambiguity is different. In the literature on limited participation in the presence of ambiguity, investors are ambiguous about individual assets' expected payoffs and volatility. Easley et al. (2014) also investigate the ambiguity of correlation, however the ambiguity is

¹ Here we assume the existence of two different types of investors. However, for simplicity, heterogeneity among investors in the same category is ignored.

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