Idiosyncratic tail risk and expected stock returns: Evidence from the Chinese stock markets

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**A R T I C L E   I N F O**

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**A B S T R A C T**

We estimate idiosyncratic tail risk according to the extreme value theory. Both portfolio analyses and cross-sectional regressions suggest a significant negative relationship between the idiosyncratic tail risk and the expected returns in Chinese stock markets after controlling for other risk measures including size, book-to-market ratio, beta, momentum, short-term reversals, liquidity, idiosyncratic volatility, downside beta, co-skewness, co-kurtosis, idiosyncratic skewness, idiosyncratic kurtosis, value at risk and maximum daily returns. Turnover explains the negative effect of the idiosyncratic tail risk in Chinese stock markets where individual investors dominate the markets and short sales are constrained.

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1. Introduction

Tail risk is very important in asset pricing when the returns are asymmetrically distributed and investors are averse to disasters. Menezes et al. (1980) suggested that investors tend to avoid positions that might cause enormous losses, although with low probability. Rietz (1988) and Barro (2006) demonstrate that rare disasters or tail risks are important in explaining some of the puzzles in asset pricing. Many studies have examined the relationship between systematic tail risk and expected market returns (Allen et al., 2012; DiTraglia and Gerlach, 2013; Kelly and Jiang, 2014; Chabi-Yo et al., 2015; Oordt et al., 2016). The role of idiosyncratic tail risk in affecting stock return attracted much less attention (Huang et al., 2012).

A large number of studies have shown that idiosyncratic risk affects asset prices. Merton (1987) proposed a capital market equilibrium model with incomplete information, which indicates that the idiosyncratic risk is positively correlated with expected stock returns. Ang et al. (2006) differentiated between systematic volatility and idiosyncratic volatility and studied their different roles in asset pricing empirically. By contrast, they found that the idiosyncratic risk is negatively related with expected returns, namely, the “idiosyncratic volatility puzzle”. In this paper, we separate idiosyncratic tail risk from systematic tail risk and investigate how the idiosyncratic tail risk is priced in returns.

Specifically, we follow the extreme value method in Huang et al. (2012) and estimate the idiosyncratic tail risk of each stock in the Chinese market with their residual returns from the three-factor Fama–French model (Fama and French, 1992; Fama and French, 1993). We employ univariate portfolio-level analysis, bivariate portfolio-level analysis and firm-level Fama–MacBeth regressions (Fama and MacBeth, 1973) to examine the relationship between the idiosyncratic tail risk and

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cross-sectional expected returns. Our findings show that both the “idiosyncratic tail risk puzzle” and “idiosyncratic volatility puzzle” exist in the Chinese stock market. Cross-sectionally, the idiosyncratic tail risk is significantly correlated with the expected return after we control for size, book-to-market ratio, beta, momentum, reversal, liquidity, downside beta, co-skewness, co-kurtosis, idiosyncratic skewness and idiosyncratic volatility.

Our study sheds light on the empirical asset pricing research, and our findings are of great significance to portfolio construction and risk management. Our paper contributes to the literature in three ways. First, we assume that the tail of stock returns follows a generalized extreme value (GEV) distribution and uses maximum likelihood estimation (MLE) to create a left tail index to measure the idiosyncratic tail risk. Value at risk (VaR) is frequently used to measure tail risk. However, the calculation of VaR requires a subjective confidence level or higher-order moments. Since the GEV distribution is much more generalized than the other distribution assumptions, our method avoids specifying the underlying distribution of asset returns or considering the leptokurtosis and the asymmetric characteristics of stock returns. The big data in our paper also avoids the significant estimation error in estimating the tail risk in macroeconomics (Barro, 2006). The idiosyncratic tail risk we calculate differs systematically from the other common risk measures including size, book-to-market ratio, beta, momentum, reversal, liquidity, idiosyncratic volatility, co-skewness, co-kurtosis, idiosyncratic skewness, idiosyncratic kurtosis and VaR. The idiosyncratic tail risk contains important information that affects stock price.

Second, the high volatility and frequent market crash events in the Chinese stock market provide a new scenario to investigate the relationship between idiosyncratic tail risk and expected returns and compare this relationship with that in the U.S. market. Huang et al. (2012) suggested a significant positive premium on firm-specific extreme downside risk in the U.S. stock market. Our paper finds a robust, significant, negative relationship between the idiosyncratic tail risk and returns. The “idiosyncratic tail risk puzzle” and the “idiosyncratic volatility puzzle” both exist but cannot explain each other.

Finally, we find that turnover explains the “idiosyncratic tail risk puzzle” in the Chinese stock market. Our findings are consistent with the main findings in bubble and crash research (Miller, 1977; Harrison and Kreps, 1978; Scheinkman and Xiong, 2003; Chen et al., 2001; Hong and Stein, 2003). Stocks with more heterogeneous beliefs tend to have higher turnover. Hong and Stein (2003) suggested that heterogeneous opinions and short sale constraints tend to cause market crashes and negative returns in the futures. Zhang and Ikeda (2016) found that investor’ fresh disagreement negatively correlates with returns of stocks under the short sale ban in the Hong Kong Stock Exchange. Individual investors dominate the Chinese stock markets. Heterogeneous opinions and high turnover are more likely to happen. The constraints on short sales dramatically increase the idiosyncratic tail risk and the probability of a stock price crash, leading to negative future returns.

The paper is organized as follows. Section 2 presents the data and methodology. Section 3 presents the empirical results and robustness test. Section 4 contains a conclusion.

2. Data and methodology

2.1. Data

We collect daily and monthly returns of all stocks in Chinese A-share markets between January 1997 and December 2015 from the CSMAR (China Securities Market & Accounting Research) database in WRDS (Wharton Research Data Service). The 10% price limit policy took effect at the beginning of 1997. We exclude stocks that have been listed for less than one year and returns on the first day after the initial public offering. We use the value-weighted market return from CSMAR database. We use the one-year deposit rate as the risk-free rate. We also obtain the turnover, total market capitalization, book-to-market ratio, risk-free rate, and the daily and monthly Fama–French three-factor data from the CSMAR database.

2.2. Estimation of the idiosyncratic tail risk

According to Huang et al. (2012), we take the following steps to estimate the idiosyncratic tail risk.

First, for each stock i in each month, we run the time-series three-factor models in Eq. (1), with their daily returns in the month. The regression residuals ε_{it} are the idiosyncratic returns on stock i at time t.

\[ R_{it} - r_{ft} = \alpha_i + \beta^{MKT}_i (MKT_t - r_{ft}) + \beta^{SMB}_i SMB_t + \beta^{HML}_i HML_t + \varepsilon_{it}, \]

where \( R_{it} \) is the return on stock i at day t, \( MKT_t \) is the market return on day t, and \( r_{ft} \) is the risk-free rate at day t. \( SMB_t \) and \( HML_t \) represent daily Fama–French risk factors of size and book-to-market ratio, respectively.

Second, for each stock i in each month, we use the idiosyncratic returns of the past 250 days before the last day of the month to estimate the idiosyncratic tail risk. According to the block minima method, we choose the minimum idiosyncratic returns in every block of 20 days and denote them as \( X_1, X_2,..., X_n \). These minimum values form an extreme sample.

Last, for each stock i in each month, with the extreme sample formed in the last step, we use the maximum likelihood estimation to compute the tail index based on the GEV distribution. We choose the \( \xi \) to maximize the following logarithmic likelihood function of GEV distribution:

\[ l(\mu, \sigma, \xi) = -n \log \sigma - \left( \frac{1}{\xi} + 1 \right) \sum_{i=1}^{n} \log \left( 1 + \frac{\xi X_i - \mu}{\sigma} \right) - \frac{n}{1 + \xi} \left( 1 + \frac{\xi X_i - \mu}{\sigma} \right)^{-\frac{1}{\xi}} \]

where \( 1 + \frac{\xi X_i - \mu}{\sigma} > 0 \). We denote the idiosyncratic tail risk on stock i for each month t as \( ITR_{it} \). We have \( ITR_{it} = \hat{\xi} \).

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