Default Risk, Macroeconomic Conditions, and the Market Skewness Risk Premium

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Abstract

Previous literature finds that stocks with low market skewness risk outperform stocks with high market skewness risk. Using the portfolio sort approach, we show that this market skewness risk premium is much more pronounced among stocks with low default risk or under good economic conditions. The premium vanishes among stocks with high default risk or under poor economic conditions. Further, the market skewness risk is negatively priced only for stocks with low default risk or in good economic times. It is not priced when firm-level default risk is high or when macroeconomic conditions are bad. Our findings suggest that the market skewness risk premium and the pricing of market skewness risk are conditional on both firm-level default risk and country-level macroeconomic conditions. This is because investors' aversion to default risk and downside market risk changes their attitudes towards positive market skewness risk.

JEL classification: G01; G12

Keywords: Asset pricing; positive skewness preference, market skewness risk premium; default risk; macroeconomic conditions; state-dependent risk aversion

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1 Introduction

Asset pricing theory suggests a positive relation between risk and expected returns on investment. However, empirical evidence points to a negative relation between various skewness-based measures and expected stock returns.[1] In particular, Chang, Christoffersen, and Jacobs (2013) estimate the market skewness risk of a stock using the exposure of stock returns to innovations in option-implied market skewness. They report that stocks with negative exposure to market skewness innovations outperform stocks with positive exposure. According to rational expectations, the market skewness risk effect can be viewed as a risk premium due to investors' preference for positive skewness and willingness to receive a lower return (see Arditti, 1967; Kraus and Litzenberger, 1976; Harvey and Siddique, 2000; Chabi-Yo, 2012).

In this study, we examine whether the market skewness risk premium and the pricing of market skewness risk are conditional on firms' default risk and macroeconomic conditions. Our study builds on the seminal works on risk aversion by Pratt (1964) and Arrow (1965) and those on positive skewness preference by Arditti (1967) and Kraus and Litzenberger (1976). These studies show that risk-averse investors prefer positive return skewness and dislike negative return skewness. Moreover, since Arrow (1965) introduced the notion of state-dependent risk aversion, several studies have shown that investors' risk aversion depends on wealth, past payoffs, and volatility (Guiso and Paiella, 2008; Bordalo et al., 2012; Gao et al., 2021).

Authors of standard structural models of default (Black and Scholes, 1973; Merton,

[1]See, for example, Arditti (1967), Kraus and Litzenberger (1976), Harvey and Siddique (2000), Conrad et al. (2013), and (Xu et al., 2019).

1974) show that default occurs when the market value of a firm's assets falls below a default threshold. Firms with large exposure - negative or positive - to market skewness are more likely to see large drops in firms' values that violate their default thresholds. Building on Merton's (1974) default model, Engle (2011) shows that negative market skewness can lead to widespread bankruptcy. Moreover, previous literature suggests that macroeconomic conditions also affect market skewness. In other words, the direction of market skewness is likely to be sensitive to macroeconomic conditions. A positive (negative) market skewness implies reduced downside market risk (increased downside market risk) due to improved investment opportunities and easy credit (reduced investment opportunities and credit contraction) (Bates, 2000; Pan, 2002; Yuan, 2005; Adrian and Rosenberg, 2008). In bad economic times, shortages of available funds could cause more failures because companies are unable to meet their debt obligations (Weinstein, 1981; Denis and Denis, 1995; Chen, 2010).

Along this line of thought, we argue that default risk and macroeconomic conditions constitute essential conditioning factors for the market skewness risk premium. This is because they significantly alter investors' attitudes towards market skewness risk. When the default risk of a firm is low or when macroeconomic conditions are good, investors are less concerned about the firm defaulting or a possibility of a large economic downturn. Their attitudes towards market skewness risk are primarily determined by their preference for positive skewness. This leads to a strong market skewness risk premium. In contrast, when a firm is close to its default threshold or operates under poor economic conditions, the firm is more vulnerable to default risk and downside market risk. Investors' attitudes towards positive market skewness risk change accordingly and reduce the market skewness risk premium. Therefore, the market skewness risk premiums are likely to vary with firms' default risk and macroeconomic conditions. We expect to observe the larger market skewness risk premiums among stocks with low default risk or under good economic conditions. On the other hand, we also expect to observe the smaller market skewness risk premiums among stocks with high default risk or under poor economic conditions.

Following Chang et al. (2013), we measure the innovations in market skewness using the market skewness implied by the S&P 500 index option prices (i.e., the option-implied market skewness). A stock's market skewness risk is estimated as the loading of its excess returns on the innovations in the implied market skewness (market skewness beta). We test the conditionality of the market skewness risk premium and the pricing of market skewness risk at both the firm level and the aggregate macroeconomic level. At the firm level, we employ two commonly used measures of default risk: the default likelihood indicator of Vassalou and Xing (2004) and the O-score of Ohlson (1980). At the macroeconomic level, we employ the expected market risk premium and the term spread to identify good and bad economic times following Petkova and Zhang (2005) and Petkova (2006). Both measures have been shown to capture investment opportunities and credit conditions.

Consistent with Chang et al. (2013), we find a strong market skewness risk premium that stocks with the largest negative market skewness beta outperform those with the largest positive market skewness. More importantly, the market skewness premium is concentrated in stocks with low default risk, large market capitalization, low book-to-market ratio, or in good economic times. The premium, however, vanishes among stocks with high default risk, small market capitalization, high book-to-market ratio, or in bad economic times. We also confirm such heterogeneity in the pricing of market skewness risk in the cross-section of stock returns. Specifically, the results from our Fama and MacBeth (1973) cross-sectional regressions demonstrate that market skewness risk is negatively priced only among stocks with low default risk or in good economic times. It is not priced among stocks with high default risk or in bad economic times. Importantly, using the two-way sorted portfolios approach, we find that the market skewness premium can be observed only for firms with low default risk in good macroeconomic times. Results of the cross-sectional regressions confirm the findings from the portfolio sorts approach.

A large body of literature has examined the impact of skewness-based measures on expected stock returns. They propose various measures to capture multiple aspects of asset return skewness. Arditti (1967) finds a negative relation between total skewness and expected stock returns. Kraus and Litzenberger (1976) add a systematic skewness measure into the asset pricing model. They report that co-skewness is negatively priced in the expected stock returns. Harvey and Siddique (2000) extend the study of Kraus and Litzenberger (1976) and show that conditional co-skewness is a pricing factor. Other studies examine the impacts of idiosyncratic skewness (Mitton and Vorkink, 2007), expected idiosyncratic skewness (Boyer et al., 2009), risk-neutral skewness (Conrad et al., 2013; Bali and Murray, 2013), realized skewness (Amaya et al., 2015), and return asymmetry (Xu et al., 2019) on expected stock returns. Our study relates to a recent strand of literature that investigates the market skewness risk premium and the pricing of market skewness risk in the cross-section of stock returns (Chabi-Yo, 2012; Chang et al., 2013).

Our analysis differs from the behavioral literature that attributes investors' preference for holding stocks with positive skewness to lottery-like payoffs. For instance, Barberis and Huang (2008) find that positively skewed securities have lottery-like features and are highly sought after by investors. As a result, these stocks are overpriced and earn lower expected returns. Kumar (2009) defines stocks with high idiosyncratic skewness as lottery-like stocks and shows that individual investors prefer them. Boyer et al. (2010), Bali et al. (2011), and Conrad et al. (2014) report that lottery-like stocks have higher skewness and lower expected returns. Bordalo et al. (2013), Dertwinkel-Kalt and Köster (2020), and Cosemans and Frehen (2021) attribute the lower expected returns of lottery-like stocks to their salient past returns. In contrast, our study follows a rational framework based on risk aversion and positive skewness preference. Our results are in line with the findings of a recent study by Gao et al. (2021), who show that the return-skewness relation is dependent on variance.

We contribute to the broader literature on the negative relation between higher moments (especially skewness) of market returns and expected stock returns. We demonstrate that the market skewness premium varies with firm-level default risk and country-level macroeconomic conditions. Our results are consistent with the rational notion that high default risk and macroeconomic conditions alter investors' attitudes towards positive market skewness risk. We also contribute to the growing literature on the pricing of higher moments of returns. Specifically, we provide new insight into the pricing of market skewness risk documented by Chabi-Yo (2012) and Chang et al. (2013). We show that market skewness risk is not systematically priced but only priced for stocks with low default risk under good economic conditions. Overall, in line with the notion of state-dependent risk aversion, our results demonstrate that both the market skewness risk premium and the pricing of market skewness risk are dependent on default risk and macroeconomic conditions.

The rest of the paper proceeds as follows. Section 2 develops the hypotheses. Section 3 describes the data used in this study, the estimation of market skewness risk, and the measures of default risk. Section 4 presents the empirical results and Section 5 concludes the paper.

2 Hypotheses Development

According to Chabi-Yo (2012) and Chang et al. (2013), the pricing effect of the market skewness risk is given by:

$$E[R_i] - R_f = \lambda_0 + \lambda_1 \beta_{i,m} + \lambda_2 \beta_{\Delta SKEW_m}, \tag{1}$$

where

$$\beta_{i,m} = \frac{\sum_t (R_{i,t} - E[R_i])(R_{m,t} - E[R_m])}{\sum_t (R_{m,t} - E[R_m])^2}, \tag{2}$$

$$\beta_{\Delta SKEW_m} = \frac{\sum_t (R_{i,t} - E[R_i])(\Delta SKEW_{m,t} - E[\Delta SKEW_m])}{\sum_t (\Delta SKEW_{m,t} - E[\Delta SKEW_m])^2}, \tag{3}$$

$E[R_i]$ is the expected return on risky asset i, R_f is the return on a risk-free asset, $R_{m,t}$ is the market return, $\beta_{i,m}$ is the loading on market excess returns, $\Delta SKEW_m$ is the innovation in the market skewness, $\beta_{\Delta SKEW_m}$ is the loading on market skewness, λ_1 denotes the price of $\beta_{i,m}$, and λ_2 denotes the price of $\beta_{\Delta SKEW_m}$. Chabi-Yo (2012) develops a pricing kernel function by including additional terms in the Taylor expansion of a representative investor's marginal utility. The author demonstrates that the price of the market skewness risk is negative when the skewness preference is over twice as large as the kurtosis preference. That is, when investors' preference for positive skewness is sufficiently large relative to their preference for kurtosis, stocks with high market skewness risk are more desirable than stocks with low market skewness risk. Therefore, stocks with positive market skewness risk have lower expected returns than those with negative market skewness risk. Equation (1) implies a strong negative relation between $\beta_{\Delta SKEW_m}$ and stock returns, $\lambda_2<0$, that lends itself to empirical testing.

Risk aversion is the central theory in investment decisions. The Arrow-Pratt notion of risk aversion suggests that risk-averse investors require a risk premium as compensation for taking higher risks in their investment (Pratt, 1964; Arrow, 1965). Arditti (1967) and Kraus and Litzenberger (1976) posit the idea of positive skewness preference that risk-averse investors prefer positive return skewness and dislike negative return skewness. This is because skewness captures asymmetric gain and loss. As a result, investors are willing to accept lower expected returns from an investment with positive skewness. This explains the negative relation between market skewness risk and expected stock returns documented by Chabi-Yo (2012) and Chang et al. (2013).

Building on the notions of risk aversion and positive skewness preference, we hypothesize that the market skewness risk premium and the pricing of market skewness risk are conditional on default risk. Vassalou and Xing (2004) demonstrate that default risk is a systematic risk factor and investors require a risk premium for holding stocks that are close to their default threshold. We further argue that investors' attitudes towards market skewness risk are altered by firms' default risk. Specifically, as long as the risk of default is low, investors have a strong preference for positive skewness. They require lower returns on stocks with positive market skewness risk. In the meantime, they demand higher returns on stocks with negative market skewness risk. This leads to a strong market skewness risk premium. However, large degrees of market skewness risk (either positive or negative exposures to market skewness) are associated with an increased risk of default. Investors would also require a higher return on stocks with positive market skewness risk and high default risk. This can diminish the market skewness risk premium. As a result, the market skewness risk premium is likely to change with firms' default risk.

The market skewness risk premium and the pricing of market skewness risk are also likely to be affected by macroeconomic conditions. Bates (2000), Pan (2002), Yuan (2005), and Engle (2011) show that bad economic times are characterized by negative market skewness and increased downside market risk. Ang et al. (2006) find that investors demand higher returns for holding stocks with greater downside market risk. Moreover, poor macroeconomic conditions make firms default more likely, which worries investors. Under good macroeconomic conditions, market returns tend to be positively skewed and the default is less likely. Investors' preference for positive skewness dominates their risk attitudes. They demand lower returns on stocks with positive market skewness risk and higher returns on stocks with negative market skewness risk in good economic times. As a result, the strong market skewness risk premium dominates. But in bad macroeconomic times, investors change their attitudes towards positive market skewness risk because, now, what dominates their decisions are both greater downside market risk and higher default risk. Consequently, investors require higher returns on stocks with positive market skewness risk: the market skewness risk premium is reduced in bad economic times.

3 Data and Measures

Our dataset contains all stocks listed on the New York Stock Exchange (NYSE), American Stock Exchange (AMEX), and Nasdaq. The stock return series are from the Center for Research in Security Prices (CRSP) daily and monthly stock return files. We adjust the returns on delisted stocks following a widely used approach suggested by Shumway (1997). We obtain the accounting data from the CRSP/Compustat Merged Database and retrieve data on Fama and French's three factors, the momentum factor, and the risk-free rate from Kenneth French's website.[2] All the variables required in the calculations of the term spread and the expected market premium are from the Federal Reserve Board Statistical historical data.[3] S&P 500 index options data including strike prices, bid and ask prices, implied volatilities, and expiration dates are collected from OptionMetrics. Using option prices has advantages because they contain forward-looking information and can capture the expectations of market participants. Since option data from OptionMetrics is available from 1996, our sample covers the period from January 1996 to December 2013.

Following Chang et al. (2013), we make several adjustments to our sample. First, we calculate the average of the bid and ask quotes for each option contract. We exclude options with zero bid prices and those with average quotes that are less than $3/8 because these prices might not reflect the true value of an option. Second, we eliminate all the quotes that do not meet the standard no-arbitrage conditions. Third, following Aït-Sahalia and Lo (1998), we remove in-the-money call options whose strike prices are less than 97% of the underlying asset prices and in-the-money put options whose strike prices are more than 103% of the underlying asset prices because these options are less liquid. Finally, as recommended by Jiang and Tian (2005), we exclude in-the-money options with a maturity of less than one week from our sample to avoid potential issues related to liquidity and market microstructure. To calculate the skewness measure for any particular day of trading, we require at least two out-of-the-money calls and two out-of-the-money puts, so that we have at least four options over an available moneyness range.

[2]http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/
[3]http://www.federalreserve.gov/econresdata/statisticsdata.htm

3.1 Calculation of innovations in implied market skewness

Employing the model-free approach of Bakshi and Madan (2000), Carr and Madan (2001), Bakshi et al. (2003), Jiang and Tian (2005), and Chang et al. (2013), we estimate the skewness of market returns implied by S&P 500 index option prices over a 30-day horizon based on options with one-month maturity. Appendix A provides the calculation of the implied market skewness in more detail. To mitigate the impact of outliers in our analysis, we winsorize the implied market skewness at the 1^{st} and the 99^{th} percentiles.[4]

The innovations in the implied market skewness are the residuals estimated by fitting an autoregressive moving average (henceforth ARMA) (1,1) model to the time series of the implied market skewness. This method removes most of the autocorrelation from the data. We use the entire time series of the market skewness to estimate the ARMA parameters, and then use those parameters to calculate the innovation in the implied market skewness. The resulting model has the following functional form:

$$\Delta SKEW_t = 100 \times \left(SKEW_t - 0.9615 \times SKEW_{t-1} + 0.3540 \times \Delta SKEW_{t-1} + 0.0730\right), \quad (4)$$

where $SKEW_t$ is the implied market skewness at time t and $\Delta SKEW_t$ is the innovation in the implied market skewness. Our estimated parameters are comparable to those reported in Chang et al. (2013).[5]

We then follow Chang et al. (2013) and use daily data within a month to estimate the monthly market skewness beta for each stock. We require at least 17 observations in the

[4] We also use data without winsorising and the alternative method of deleting any extremely large and small values of the implied market skewness. The results remain qualitatively unchanged and are available upon request.

[5] The results are not reported here, but are available from the authors on request.

month to be estimated. The model has the following functional form: [6]

$$R_{i,\tau} - R_{f,\tau} = \beta_0 + \beta_{i,m}\left(R_{m,\tau} - R_{f,\tau}\right) + \beta_{\Delta SKEW_m} \Delta SKEW_{m,\tau} + \epsilon_{i,\tau}, \tag{5}$$

where $R_{i,\tau}$ is the daily return on stock i on day τ, $R_{f,\tau}$ is the daily risk-free rate, and $R_{m,\tau}$ is the daily market return on all stocks listed on the NYSE, AMEX, and Nasdaq. The parameter $\beta_{\Delta SKEW_{m,\tau}}$ is the market skewness risk measure, that is, the loading of the excess returns of stock i on the innovations in the implied market skewness estimated from S&P 500 index option prices.

3.2 Measures of default risk

The literature has proposed multiple measures of default risk. In this paper, we adopt two popular measures employed in existing studies: the default likelihood indicator (*DLI* henceforth) of Vassalou and Xing (2004) and the O-score of Ohlson (1980). The *DLI* has a forward-looking property, which reflects the expectation of investors about the market value of a firm. The O-score of Ohlson (1980) is the accounting-based measure for predicting bankruptcy. Following Ohlson (1980), we use the coefficients of nine accounting ratios to construct the O-score of a firm. Appendix C provides a detailed estimation of the O-score. Stocks with high O-scores have higher default risk. Griffin and Lemmon (2002) argue that the O-score as a comprehensive multidimensional measure of economic strength is better than measures that are based on a single variable.

[6] We also use another model, adding market volatility, $R_{i,\tau} - R_{f,\tau} = \beta_0 + \beta_{i,m}\left(R_{m,\tau} - R_{f,\tau}\right) + \beta_{\Delta SKEW_m} \Delta SKEW_{m,\tau} + \beta_{\Delta VOL_m} \Delta VOL_{m,\tau} + \epsilon_{i,\tau}$. Our results (untabulated) are insensitive to this alteration.

3.2.1 Calculation of the default likelihood indicator

Following Vassalou and Xing (2004), we estimate *DLI* of a firm at time t, denoted $P_{def,t}$, from the following model:

$$P_{def,t} = P\left(V_{t+T} \leq F_t \mid V_t\right) = N\left(-d_2\right) = N\left[-\frac{ln\left(\frac{V_t}{F_t}\right) + \left(\mu - \frac{\sigma_V^2}{2}\right)T}{\sigma_V\sqrt{T}}\right], \qquad (6)$$

where V_t denotes the market value of a firm's assets at time t, σ_V is the volatility of the market value of the firm's assets, F_t is the book value of the firm's debt at time t, with a maturity date of T, $N(\bullet)$ denotes the cumulative density function of the standard normal distribution, and μ is the drift rate of the firm's asset value. Appendix B explains the estimation procedures. Stocks with a high *DLI* have high default risk.

4 Empirical Results and Analysis

Panel A of Table 1 presents the descriptive statistics of the market skewness beta ($\beta_{\Delta SKEW_m}$), the default likelihood indicator (*DLI*), the O-score, market value (*MV*), and the book-to-market ratio (*B/M*) for the period from 1996 to 2013. The mean value of $\beta_{\Delta SKEW}$ is -0.15, indicating that, on average, the exposure of stock returns to innovations in the option-implied market skewness is negative. Panel B of Table 1 shows the correlation coefficients between the variables. $\beta_{\Delta SKEW}$ and the default risk measures have low correlation coefficients (ranging from -0.04 to -0.08), suggesting that market skewness risk and default risk are two distinct types of risk. It is worth noting that *DLI* and O-score are positively correlated, with a correlation coefficient of 0.63, suggesting that the two measures largely agree on the classification of default risk. Moreover, *MV* and *B/M* are highly correlated with *DLI* and O-score. This is consistent with the findings of Vassalou and Xing (2004).

4.1 Default risk and the market skewness risk premium

4.1.1 One-way portfolio sorts

Fama and French (2008) point out that the portfolio sorts approach provides a clear pattern of returns and allows a double-check for regression estimates. In this section, we first examine the return performance of portfolios formed on market skewness risk. At the end of each month, we sort stocks based on their lagged market skewness risk ($\beta_{\Delta SKEW_m}$), and form quintile portfolios. We record the monthly returns on each portfolio in the subsequent month and rebalance the portfolios monthly. Table 2 reports the monthly value-weighted average returns and the abnormal returns of portfolios formed on market skewness risk. Quintile portfolio 1 contains stocks with the lowest $\beta_{\Delta SKEW_m}$. Quintile portfolio 5 contains stocks with the highest $\beta_{\Delta SKEW_m}$. The last column, labelled 1–5, represents the long-short portfolio that holds stocks in quintile portfolio 1 and shorts stocks in quintile portfolio 5.

The abnormal returns are the intercepts estimated from the capital asset pricing model (henceforth CAPM) of Sharpe (1964) and Lintner (1965), the Fama and French (1993) three-factor model (henceforth FF3), and the Carhart (1997) four-factor model (henceforth Carhart) in the following equations:

$$R_{p,t} - R_{f,t} = \alpha_{CAPM} + \beta_{p,m} \left(R_{m,t} - R_{f,t}\right) + \epsilon_{p,t}, \tag{7}$$

$$R_{p,t} - R_{f,t} = \alpha_{FF3} + \beta_{p,m} \left(R_{m,t} - R_{f,t}\right) + s_p SMB_t + h_p HML_t + \epsilon_{p,t}, \tag{8}$$

$$R_{p,t} - R_{f,t} = \alpha_{Carhart} + \beta_{p,m}\left(R_{m,t} - R_{f,t}\right) + s_p SMB_t + h_p HML_t + m_p UMD_t + \epsilon_{p,t}, \qquad (9)$$

where $R_{p,t}$ is the return on portfolio p in month t, SMB_t (Small-Minus-Big), HML_t (High-Minus-Low), and UMD_t (Up-Minus-Down) are the returns on the mimicking portfolios for size, book-to-market equity, and momentum, respectively.

Panel A of Table 2 presents the results for the period from 1996 to 2007, which has the same sample period as the study by Chang et al. (2013). Panel B reports the results for the extended sample period, from 1996 to 2013. Overall, Table 2 shows a negative relation between market skewness risk and portfolio returns. Consistent with Chang et al. (2013), portfolio 1 significantly outperforms portfolio 5 at the 5% level, with a monthly average return of 0.90% (t = 2.66), a CAPM alpha of 0.85% (t = 2.38), a FF3 alpha of 0.82% (t = 2.36), and a Carhart alpha of 1.07% (t = 3.05), for the long-short portfolio (1-5) in Panel A. The results suggest that a trading strategy of buying stocks in portfolio 1 and short-selling stocks in portfolio 5 earns significant abnormal returns even after adjusting for various risk factors. In Panel B, although the average return and abnormal returns on the long-short portfolio are still statistically significant at the 5% level, they are smaller in magnitude than those reported in Panel A. The results indicate that the market skewness risk premium on the long-short portfolio becomes smaller after 2007.

Panel A of Table 3 reports various firm characteristics for portfolios formed on the market skewness risk. They are calculated as the time-series averages of cross-sectional means. The reported firm characteristics are the market value (*MV*), book-to-market ratio (*B/M*), total liabilities-to-assets ratio (*TLTA*), cash flow-to-assets ratio (*CF*), cash-to-assets ratio (*CH*), and return-on-assets ratio (*Profitability*). Appendix E provides detailed explanations of the measures of firm characteristics. We find that portfolios 1 and 5 consist of firms with large negative and positive market skewness betas. The mean market skewness beta of portfolios 1 and 5 are −9.85 and 9.61, respectively. Moreover, firms in these two portfolios have several similar characteristics. Compared with those in other portfolios, they tend to be firms with lower market value, generate negative profits and cash flows from their operations, and hold more cash.[7] On the other hand, firms with high market skewness risk (portfolio 5) have slightly lower B/M than firms with low market skewness risk (portfolio 1), indicating that firms in portfolio 5 have more growth opportunities than firms in portfolio 1. Panel B of Table 3 presents the means of the default risk measures for each portfolio. The results indicate that firms with low and high market skewness risk have a higher default risk than firms in other quintile portfolios, with high values of both *DLI* and O-score.

4.1.2 Two-way portfolio sorts

The one-way portfolio sorts approach fails to capture how a risk premium (or an anomaly) varies with other factors (Fama and French, 2008). As stock returns are likely to be determined by multiple factors, there is an increasing trend of using approaches that simultaneously sort returns on more than a single factor in the analysis of portfolio performance, such as the two-way independent sorts method (Conrad et al., 2003; Fama and French, 2008). To examine how the market skewness risk premiums on the long-short portfolio vary across the different degrees of default risk, we perform a two-way portfolio sorts approach. Specifically, at the end of each month, we sort all stocks into quintile portfolios according to their lagged market skewness beta. Independently, we sort all stocks again into three portfolios based on their past *DLI* or O-score using the 30$^{\text{th}}$ and 70$^{\text{th}}$ percentiles as

[7] We also examined the accounting ratios that construct the O-score for market skewness risk portfolios. The results show a similar pattern to those reported for other firm characteristics.

the breakpoints. Then, we match five market skewness risk portfolios with three default risk portfolios together and produce a total of 15 *DLI* - $\beta_{\Delta SKEW_m}$ portfolios and 15 O-score - $\beta_{\Delta SKEW_m}$ portfolios. We hold each portfolio for the subsequent month and rebalance the portfolios monthly.

Panel A of Table 4 reports the FF3 alphas for the two-way sorted portfolios. Holding *DLI* and O-score fixed, among stocks with low default risk (DLI_1 and $O\text{-}score_1$), portfolio 5 produces lower abnormal returns. However, portfolio 1 generates higher abnormal returns. For DLI_1, the FF3 alpha is 0.48% ($t = 1.63$) per month for portfolio 5 and 1.38% ($t = 3.66$) per month for portfolio 1. For $O\text{-}score_1$, the FF3 alpha is 0.03% ($t = 0.08$) per month for portfolio 5 and 1.36% ($t = 3.43$) per month for portfolio 1. The results are in line with our hypothesis that when default risk is low, positive skewness preference dominates investors' attitudes. They require much lower returns on stocks with positive market skewness risk and low default risk (DLI_1 - $\beta_{\Delta SKEW_{m}5}$ and $O\text{-}score_1$ - $\beta_{\Delta SKEW_{m}5}$) and demand higher returns on stocks with negative market skewness risk and low default risk (DLI_1 - $\beta_{\Delta SKEW_{m}1}$ and $O\text{-}score_1$ - $\beta_{\Delta SKEW_{m}1}$), leading to the strong market skewness risk premium of 0.90% ($t =$ 2.62) per month for *DLI* and 1.33% ($t = 3.70$) per month for $O\text{-}score_1$.

For stocks with high default risk (DLI_3 and $O\text{-}score_3$), both portfolios 5 and 1 earn higher abnormal returns. For example, the FF3 alpha of portfolio 5 is 0.98% ($t = 1.71$) and that of portfolio 1 is 0.76% ($t = 1.46$) for DLI_3. Additionally, the FF3 alpha of portfolio 5 is 1.02% ($t = 2.50$) and that of portfolio 1 is 1.44% ($t = 3.53$) for $O\text{-}score_3$. These result in the weak market skewness risk premium of -0.21% ($t =$ -0.59) per month for DLI_3 and 0.43% ($t = 0.97$) per month for $O\text{-}score_3$. The findings are consistent with our hypothesis that investors' aversion to default risk drives investors' risk attitudes when default risk is high. They require higher returns on both stocks with positive and negative market skewness risk, which diminishes the difference in returns between them.

Vassalou and Xing (2004) find that default risk is closely related to the size and book-to-market ratio of a firm. We, therefore, further investigate the robustness of the market skewness risk premiums across size and book-to-market ratio portfolios. Panel B of Table 4 presents the FF3 alphas for two-way sorted MV - $\beta_{\Delta SKEW_m}$ and B/M - $\beta_{\Delta SKEW_m}$ portfolios. Keeping MV and B/M fixed, the market skewness risk premiums are higher in MV_3 (large size) and B/M_1 (low book-to-market ratio) than in MV_1 (small size) and B/M_3 (high book-to-market ratio). These results further confirm that the market skewness risk premiums are higher among stocks with low default risk (stocks with large size and low market-to-book ratio), but vanish among stocks with high default risk (stocks with small size and high market-to-book ratio).

Overall, our results show that the market skewness risk premiums vary with default risk, market capitalization, and book-to-market ratio. The premiums are more pronounced for stocks with low default risk, large market size, and low book-to-market ratio.

4.1.3 Cross-sectional regressions

The results in Table 4 indicate that the market skewness risk premiums are significantly affected by default risk. Fama and French (2008) argue that although the portfolio sorts approach provides a clear pattern of returns across different portfolios, it is hard to draw precise inferences from unique information about average returns. The estimates from multiple regressions can provide information about marginal effects, which can be used to draw more precise inferences. In this section, we conduct a cross-sectional regression analysis. Fama and French (2008) also point out that regression estimates based on all stocks can be driven by stocks with extreme values of the explanatory variables and extreme returns. To avoid this problem, we split the full sample into three subsamples according to the default risk measures of stocks. Specifically, at the end of each month, we rank stocks based on their lagged *DLI* or O-score, using the 30$^{\text{th}}$ and 70$^{\text{th}}$ percentiles as the breakpoints, and form three subsamples. We examine the explanatory power of market skewness risk on stock returns for the subsamples of low and high default risk from the following Fama and MacBeth (1973) cross-sectional regression:

$$R_{i,t+1} - R_{f,t+1} = \lambda_0 + \lambda_1 \beta_{\Delta SKEW_{m,t}} + \boldsymbol{\lambda}_2' \boldsymbol{X}_{i,t} + \varepsilon_{i,t+1}, \tag{10}$$

where $R_{i,t+1}$ denotes the return on stock i in month $t+1$, $\beta_{\Delta SKEW_{m,t}}$ is the market skewness risk in month t, and $\boldsymbol{X}_{i,t}$ is a 3×1 vector of the lagged control variables, including $ln\,(MV)$, $ln\,(B/M)$, and MOM. $ln\,(MV)$ is the natural logarithm of the market value of equity at the end of June of year k, $ln\,(B/M)$ is the natural logarithm of the book-to-market ratio at the end of year $k-1$, and MOM is the cumulative monthly stock returns for the rolling 6-month window. The models are estimated using the weighted least squares (WLS) technique to remove noise from size since large stocks are shown to have a stronger impact on the market skewness risk premium than small stocks. To overcome the potential issues of heteroskedasticity and autocorrelation in the regression residuals, the t-statistics are computed using the robust standard errors of Newey and West (1987).

Table 5 reports the estimates from the cross-sectional regressions for the subsamples defined according to default risk. "*Low*" denotes the subsample that contains stocks with the lowest *DLI* or O-score. "*High*" denotes the subsample that contains stocks with the highest corresponding variables. "*High-Low*" denotes the difference between the high and the low subsamples. The coefficients on market skewness beta are significantly negative for the low *DLI* and O-score subsamples regardless of the control variables. Conversely, they are insignificant for the high *DLI* and O-score subsamples. For instance, with the control variables, the coefficient on $\beta_{\Delta SKEW_m}$ is -0.06 (t = -3.47) for the low *DLI* subsample and -0.07 (t = -2.91) for the low O-score subsample. In contrast, the coefficient is 0.01 (t = 0.19) for the high *DLI* subsample and 0.00 (t = -0.57) for the high O-score subsample. The results confirm that market skewness risk is significantly and negatively priced in the cross-section of expected returns for stocks with low default risk, but is not priced for stocks with high default risk.

In summary, consistent with our findings of the two-way portfolio sorts approach, the results from Fama and MacBeth (1973) regressions show that market skewness risk is significantly priced in the cross-section of expected stock returns for stocks with low default risk, but it is not priced for stocks with high default risk.

4.2 The market skewness risk premium over the business cycle

To examine the time-series variation in the market skewness risk premium over the business cycle, we use the term spread and the expected market risk premium to identify good and bad economic times. Fama and French (1989) show that the term spread is highly related to short-term fluctuations in the business cycle. Following Petkova (2006), we compute the term spread as the difference between the rates on a ten-year government bond and those on a one-year bond. We define a bad time as a period of a positive change in the term spread, representing a deterioration in macroeconomic conditions, or tight credit. We define a good time as a period of a negative change in the term spread, that is, a period of economic growth and easy credit.

To estimate the expected market risk premium, we follow Petkova and Zhang (2005) and run the following regression:

$$R_{m,t+1} = \beta_0 + \beta_1 DIV_t + \beta_2 DEF_t + \beta_3 TERM_t + \beta_4 TB_t + \varepsilon_{m,t+1}, \tag{11}$$

where $R_{m,t+1}$ is the realized market excess return between t and $t+1$, DIV_t is the dividend yield, DEF_t is the default spread, $TERM_t$ is the term spread, and TB_t is the one-month Treasury bill rate. DIV_t is the sum of the dividends of the CRSP value-weighted market portfolio over the past 12 months divided by the value of the CRSP market index. DEF_t is the difference between the yields on Moody's BAA- and AAA-rated corporate bonds. $TERM_t$ is computed by subtracting the yield on the one-year Treasury bill from the yield on the ten-year Treasury bond.

We use the ordinary least squares (OLS) technique to estimate the coefficients in Equation (11). The expected market risk premium, denoted $\hat{\gamma}_t$, is the fitted value calculated from Equation (12):

$$\hat{\gamma}_t = \hat{\beta}_0 + \hat{\beta}_1 DIV_t + \hat{\beta}_2 DEF_t + \hat{\beta}_3 TERM_t + \hat{\beta}_4 TB_t. \tag{12}$$

A "good" time is defined as a period when the expected market risk premium is lower than its mean, while a "bad" time is defined as a period when the expected market risk premium is higher than its mean.

We divide the full sample into two subsamples according to good and bad economic times and use the same portfolios formation approach as used in Table 2 to form quintile portfolios based on market skewness risk for each of the subsamples. Table 6 presents the monthly average returns and the abnormal returns on the quintile portfolios. Panels A and B report the results of the good and bad times subsamples defined by the term spread and the expected market risk premium, respectively. In line with our hypothesis, Table 6 shows that the market skewness risk premium on the long-short portfolio is significant in good times and insignificant in bad times regardless of the return measures and for both sets of subsamples. In particular, the results in Panel B support our argument that positive skewness preference drives investors' risk attitudes in good times, leading to very low returns on portfolio 5 and high returns on portfolio 1 in good times. Conversely, in bad times, risk aversion to macroeconomic risk drives investors' risk attitudes, resulting in higher returns on both portfolios 1 and 5.

We further estimate Fama and MacBeth (1973) cross-sectional regressions of monthly excess returns on the lagged independent variables separately for the "good times" and the "bad times" subsamples. Our independent variables include the market skewness beta plus the control variables of $ln\,(MV)$, $ln\,(B/M)$, and MOM. The estimates from the regressions are in Table 7. The coefficients on $\beta_{\Delta SKEW_m}$ are significantly negative at the 5% level in good times and are insignificant in bad times in both Panels A and B, regardless of the control variable. For example, the coefficient on $\beta_{\Delta SKEW_m}$ is -0.07 (t = -2.64) in the good time subsample and -0.01 (t = -0.36) in the bad time subsample in Panel A. The same coefficient is -0.08 (t = -3.45) in the good time subsample and -0.01 (t = -0.37) in the bad time subsample in Panel B. The results indicate that market skewness risk is strongly priced in the cross-section of stock returns in good economic times, but is not priced in bad economic times. This also contributes to the reason for our previous finding for the smaller market skewness risk premium after the 2007-2008 financial crisis.

4.3 The influence of both default risk and macroeconomic conditions on the market skewness risk premium

Our results so far suggest that the market skewness risk premium is high only for stocks with low default risk or in good economic times. However, we do not fully understand whether the market skewness risk premium and the pricing of market skewness risk among stocks with low default risk are conditional on macroeconomic conditions. We use the term structure to split the full sample into "good times" and "bad times" subsamples and perform the same two-way portfolio sorts tests as in Table 4. We form *DLI* - $\beta_{\Delta SKEW_m}$ and *O-score* - $\beta_{\Delta SKEW_m}$ portfolios in the good time and bad time subsamples, respectively. Table 8 shows that the significant market skewness premium only manifests itself in stocks with low default risk during good economic times and vanishes in bad times. Moreover, the premium does not exist in stocks with high default risk, regardless of the economic conditions.

We next conduct Fama and MacBeth (1973) cross-sectional regressions and explore the pricing of market skewness risk for the subsamples at high and low risk of default during good and bad economic times, respectively. Table 9 confirms that market skewness risk is only priced for stocks with low default risk in good economic times. It is not priced for stocks with low default risk in bad economic times, or for stocks with high default risk regardless of the economic conditions. Overall, our results suggest that both firm-level default risk and country-level macroeconomic conditions have strong impacts on the market skewness risk premium and the pricing of market skewness risk in the cross-section of stock returns.

5 Conclusions

The market skewness risk premium on the long-short market skewness risk portfolio has been well documented in the literature. However, the financial and economic implications of this premium are not well understood. In this study, we examine how the premiums vary with firm-level default risk and country-level macroeconomic conditions. We find that the premium is strong among stocks with low default risk or in good economic times. It disappears in stocks with high default risk or in bad economic times. Also, market skewness risk is a significant pricing factor in the cross-section of expected returns for stocks with low default risk in good economic times. However, it is not a pricing factor for stocks with high default risk or in bad economic times. Furthermore, our evidence shows that the presence of the market skewness risk premium and the pricing of market skewness risk require the joint condition of both default risk *and* macroeconomic conditions. That is, each is a necessary condition for the premium.

Previous literature shows that risk aversion and positive skewness preference affect investors' choices significantly. Our findings are consistent with this rational framework. Our results suggest that investors' attitudes towards positive market skewness risk change when firms are close to default or in bad economic times. Default risk and downside market risk dominate investors' risk attitudes when a default is more likely or in bad economic times. This neutralizes their preference for positive market skewness. Our findings have two strong implications. First, for theorists, our findings show that the market skewness risk premium and the pricing to market skewness risk are conditional on default risk and macroeconomic conditions. This implies that not only risk aversion is state-dependent, positive skewness preference and asset pricing on market skewness risk are also likely to be state-dependent.

Second, for practitioners, our findings suggest that when implementing the trading strategy on market skewness risk, investors should consider the impact of default risk and macroeconomic conditions on market skewness risk.

A potential limitation of this study is that we focus our analysis on market skewness risk in the presence of default risk and macroeconomic risk. However, market skewness risk may be affected by a broader class of risk. We call for future research on factors that potentially influence the pricing of stocks with high moments of return.

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Table 1
Descriptive statistics

The table reports the mean, standard deviation (*SD*), minimum (*Min*), 25% percentile value (*P25*), 75% percentile value (*P75*), maximum (*Max*), and correlation coefficients of market skewness risk ($\beta_{\Delta SKEW_m}$), default likelihood indicator (*DLI*), O-score, market value (*MV*), and book-to-market ratio (*B/M*). The implied market skewness is extracted from S&P 500 index option prices. The *DLI* is calculated using Merton's (1974) structure model of default. O-score is calculated following the method of Ohlson (1980). *MV* (in millions of dollars) is the firm's market capitalization. *B/M* is the book-to-market ratio of equity. The sample includes all common stocks traded on the NYSE, AMEX, and Nasdaq for the period from January 1996 to December 2013.

	$\beta_{\Delta SKEW_m}$	*DLI*	*O-score*	*MV*	*B/M*
		Panel A: Descriptive statistics			
Mean	-0.15	0.06	-0.14	1521	0.77
SD	2.95	0.09	3.14	8602	1.25
Min	-615.93	0.00	-7.50	0.23	0.00
P25	-0.75	0.00	-2.16	44	0.32
P75	0.58	0.09	1.19	642	0.89
Max	721.83	0.34	14.11	547363	294.43
		Panel B: Spearman rank correlation			
DLI	-0.08***	1.00			
O-score	-0.04***	0.63***	1.00		
MV	-0.05***	-0.45***	-0.86***	1.00	
B/M	-0.04	0.35***	0.22***	-0.31***	1.00

Table 2
The monthly returns and abnormal returns on one-way sorted portfolios

This table reports the value-weighted monthly average returns and the abnormal returns on market skewness risk portfolios. At the end of each month, the market skewness risk of each stock is estimated from the following regression:

$$R_{i,t} - R_{f,t} = \beta_0 + \beta_{i,m}\left(R_{m,t} - R_{f,t}\right) + \beta_{\Delta SKEW_m} \Delta SKEW_{m,t} + \epsilon_{i,t}$$

where $\Delta SKEW_{m,t}$ is the innovation in the implied market skewness, $\beta_{\Delta SKEW_m}$ is the market skewness risk of stock i measured as the risk loading of the stock excess returns on the innovations in the implied market skewness from S&P 500 index option prices. All stocks are then sorted into quintiles based on their lagged market skewness risk measure, $\beta_{\Delta SKEW_m}$. We record the monthly returns of each portfolio in the subsequent month and rebalance the portfolios monthly. Quintile 1 contains stocks with the lowest $\beta_{\Delta SKEW_m}$ and Quintile 5 contains stocks with the highest $\beta_{\Delta SKEW_m}$. 1-5 denotes a long-short portfolio that longs Quintile 1 and shorts Quintile 5. The abnormal returns are the intercepts from the capital asset pricing model (CAPM), the Fama and French (1993) three-factor model (FF3), and the Carhart (1997) four-factor model (Carhart). Panel A reports the results for the period from January 1996 to December 2007. Panel B reports the results for the period from January 1996 to December 2013. The t-statistics reported in parentheses are calculated using the heteroskedasticity and autocorrelation consistent covariance standard errors of Newey and West (1987). Statistical significance at the 10%, 5% and 1% levels is indicated by *, **, *** respectively. The sample includes all common stocks traded on the NYSE, AMEX, and Nasdaq.

	Quintile portfolio					
Sorting statistic	1 (lowest)	2	3	4	5 (highest)	1-5
			Panel A: 1996-2007			
Average return	1.58**	1.01**	1.08***	0.77*	0.68	0.90***
	(2.29)	(2.17)	(2.87)	(1.75)	(1.02)	(2.66)
CAPM alpha	0.80**	0.49**	0.65***	0.26**	-0.04	0.85**
	(2.08)	(2.51)	(3.28)	(2.55)	(-0.15)	(2.38)
FF3 alpha	1.09***	0.51**	0.64***	0.32***	0.27	0.82**
	(3.53)	(2.49)	(3.27)	(3.35)	(1.34)	(2.36)
Carhart alpha	1.35***	0.72***	0.64***	0.23*	0.27	1.07***
	(4.23)	(3.17)	(3.26)	(1.92)	(1.53)	(3.05)
			Panel B: 1996-2013			
Average return	1.60***	0.99***	1.07***	0.84**	0.90*	0.70***
	(3.15)	(2.89)	(3.82)	(2.42)	(1.79)	(2.61)
CAPM alpha	0.77**	0.42*	0.58**	0.25	0.11	0.66**
	(1.98)	(1.83)	(2.55)	(1.56)	(0.28)	(2.46)
FF3 alpha	0.99***	0.50*	0.61**	0.31	0.31	0.68**
	(2.86)	(1.94)	(2.38)	(1.65)	(0.96)	(2.57)
Carhart alpha	1.14***	0.57**	0.57**	0.24	0.36	0.78***
	(3.23)	(2.18)	(2.14)	(1.13)	(1.02)	(2.75)

Table 3
Firm characteristics and default risk for one-way sorted portfolios

At the end of each month, we sort stocks into quintiles based on their lagged market skewness risk measure, $\beta_{\Delta SKEW_m}$. The portfolios are held for the subsequent month and rebalanced monthly. Quintile 1 contains stocks with the lowest $\beta_{\Delta SKEW_m}$ and Quintile 5 contains stocks with the highest $\beta_{\Delta SKEW_m}$. Panel A reports firm characteristics for each quintile. The reported characteristics are the market value (MV, in millions of dollars), book-to-market ratio (B/M), total liabilities-to-assets (*TLTA*), cash flow-to-assets ratio (*CF*), cash holding-to-assets ratio (CH), and return-on-assets ratio (*Profitability*). The Appendix provides detailed explanations of the measures of firm characteristics. Panel B reports the average values of the default risk measures: default likelihood indicator (DLI) and O-score. The sample includes all common stocks listed on the NYSE, AMEX, and Nasdaq for the period from January 1996 to December 2013.

	Quintile				
	1 (lowest)	2	3	4	5 (highest)
Panel A: Firm characteristics					
$\beta_{\Delta SKEW}$	-9.85	-2.48	-0.02	2.41	9.61
MV	1195	3465	4335	3233	1157
B/M	0.64	0.66	0.66	0.60	0.57
TLTA	0.48	0.49	0.50	0.49	0.48
CF	-0.06	0.02	0.04	0.02	-0.06
CH	0.25	0.19	0.18	0.20	0.25
Profitability	-0.02	0.07	0.09	0.07	-0.03
Panel B: Default risk					
DLI	0.05	0.03	0.03	0.03	0.06
O-score	-0.38	-0.87	-0.94	-0.87	-0.39

Table 4
The monthly abnormal returns on two-way sorted portfolios

This table reports the monthly abnormal returns from the Fama and French (1993) three-factor model for two-way sorted portfolios. At the end of each month, we sort stocks into quintiles based on their lagged market skewness risk measure, $\beta_{\Delta SKEW_m}$, and independently sort stocks into three portfolios based on their lagged default likelihood indicator (DLI), O-score, market value (MV), and book-to-market ratio (B/M), using the 30$^{\text{th}}$ and 70$^{\text{th}}$ percentiles as the breakpoints. The portfolios are held for the subsequent month and rebalanced monthly. Subscript 1 represents the portfolios comprising stocks with the lowest values of the variables, while subscript 3 represents the portfolios comprising stocks with the highest values of the corresponding variables. The rows labeled 3–1 denote the return difference between the high portfolio and the low portfolio. The column labeled 1-5 denotes the return differences between the bottom and top market skewness risk portfolios. The t-statistics reported in parentheses are calculated using the heteroskedasticity and autocorrelation consistent covariance standard errors of Newey and West (1987). Statistical significance at the 10%, 5% and 1% levels is indicated by *, **, *** respectively. The sample period is from January 1996 to December 2013.

	Quintile portfolio					
	1 (lowest)	2	3	4	5 (highest)	1-5
Panel A: Portfolios based on the default risk measures						
DLI_1	1.38***	0.39	0.62**	0.43**	0.48	0.90***
	(3.66)	(1.52)	(2.34)	(2.34)	(1.63)	(2.62)
DLI_2	0.81**	0.43	0.28	0.06	-0.24	1.05***
	(2.03)	(1.41)	(1.17)	(0.22)	(-0.70)	(2.83)
DLI_3	0.76	0.66**	0.50	0.93**	0.98*	-0.21
	(1.46)	(2.08)	(1.07)	(2.04)	(1.71)	(-0.59)
3-1	-0.62	0.26	-0.13	0.50	0.50	
	(-1.27)	(1.05)	(-0.34)	(1.30)	(0.92)	
$O\text{-}score_1$	1.36***	0.52	0.68**	0.39*	0.03	1.33***
	(3.43)	(1.63)	(2.25)	(1.66)	(0.08)	(3.70)
$O\text{-}score_2$	1.02***	0.64**	0.58***	0.32	0.37	0.65*
	(2.89)	(2.53)	(2.67)	(1.57)	(1.28)	(1.95)
$O\text{-}score_3$	1.44***	0.71***	0.57**	0.22	1.02**	0.43
	(3.53)	(2.62)	(2.28)	(0.87)	(2.50)	(0.97)
3-1	0.08	0.19	-0.11	-0.17	0.99***	
	(0.21)	(0.67)	(-0.52)	(-0.66)	(2.94)	
Panel B: Portfolios based on market value and book-to-market ratio						
MV_1	2.48***	1.45***	1.19***	1.38***	2.23***	0.25
	(4.38)	(4.42)	(4.09)	(3.97)	(3.96)	(1.20)
MV_2	0.79**	0.51**	0.46**	0.32	0.21	0.58**
	(2.04)	(2.11)	(2.11)	(1.32)	(0.74)	(2.50)
MV_3	0.94***	0.49*	0.63**	0.29	0.21	0.73**
	(2.68)	(1.81)	(2.38)	(1.60)	(0.59)	(2.36)
3-1	-1.54***	-0.96***	-0.57***	-1.09***	-2.02***	
	(-3.34)	(-3.50)	(-2.66)	(-3.89)	(-3.71)	
B/M_1	1.12***	0.49*	0.71**	0.36*	0.33	0.79*
	(3.15)	(1.88)	(2.48)	(1.67)	(0.97)	(1.85)
B/M_2	0.99***	0.41	0.39	0.28	0.36	0.63**
	(2.69)	(1.43)	(1.61)	(1.30)	(1.04)	(2.18)
B/M_3	1.10***	0.93***	0.54**	0.25	0.78*	0.33
	(2.94)	(2.79)	(2.49)	(1.18)	(1.93)	(1.07)
3-1	-0.02	0.44**	-0.18	-0.11	0.44	
	(-0.06)	(2.01)	(-0.87)	(-0.69)	(1.06)	

Table 5
Fama-MacBeth (1973) regressions for the default risk subsamples

At the end of each month, we split the full sample into three subsamples based on the stocks' default likelihood indicators (*DLI*) and O-score using the 30th and 70th percentiles as the breakpoints. "*Low*" denotes the subsample that consists of stocks with the lowest value of the variables. "*High*" denotes the subsample that consists of stocks with the highest value of the corresponding variables. "*High-Low*" denotes the difference between the high and low subsamples. For each month, we estimate Fama and MacBeth (1973) cross-sectional regressions of monthly excess returns on the lagged market skewness beta ($\beta_{\Delta SKEW_m}$) and the lagged control variables of size ($ln(MV)$), book-to-market ratio ($ln(B/M)$) and momentum (*Mom*) for the subsamples. $ln(MV)$ is the natural logarithm of the firm's market value of equity at the end of June of year k, $ln(B/M)$ is the natural logarithm of the book-to-market ratio for the fiscal year ending in year $k-1$, and *Mom* is the cumulative compounded returns over the last 6 months. The sample period is from January 1996 to December 2013. The t-statistics reported in parentheses are calculated using the heteroskedasticity and autocorrelation consistent covariance standard errors of Newey and West (1987).

	Constant	$\beta_{\Delta SKEW_m}$	$ln(MV)$	$ln(B/M)$	*Mom*
Low DLI	0.66**	-0.05**			
	(2.15)	(-2.44)			
	1.01	-0.06***	-0.02	0.06	-0.04
	(0.92)	(-3.47)	(-0.38)	(0.59)	(-0.10)
High DLI	1.46***	0.02			
	(2.90)	(0.63)			
	1.25	0.01	-0.04	0.37*	-0.27
	(0.66)	(0.19)	(-0.31)	(1.76)	(-0.33)
High-Low	0.80**	0.07*			
	(2.11)	(1.75)			
	0.23	0.06*	-0.02	0.31*	-0.23
	(0.15)	(1.94)	(-0.16)	(1.74)	(-0.46)
Low O-score	0.67*	-0.06**			
	(1.77)	(-2.17)			
	0.42	-0.07***	0.00	0.01	0.08
	(0.29)	(-2.91)	(0.02)	(0.08)	(0.15)
High O-score	0.72**	0.00			
	(2.20)	(-0.08)			
	2.24	-0.01	-0.12	0.15	-0.02
	(1.65)	(-0.57)	(-1.35)	(1.17)	(-0.03)
High-Low	0.05	0.06*			
	(0.22)	(1.78)			
	1.82	0.05*	-0.12	0.14	-0.10
	(1.54)	(1.92)	(-1.53)	(1.07)	(-0.35)

Table 6
The monthly returns and abnormal returns on one-way sorted portfolios during good times and bad times

This table reports the value-weighted monthly average returns and abnormal returns on portfolios formed on market skewness risk during good and bad times. Following Petkova (2006) and Petkova and Zhang (2005), we estimate the term spread and the expected market risk premium to identify "good" and "bad" times. A period with a positive change in the monthly term spread or a period when the expected market risk premium is above the mean are defined as "bad" time, while a period with a negative change in the monthly term spread or a period when the expected market risk premium is below the mean are defined as "good" time. We split the full sample into good times and bad times subsamples. At the end of each good (bad) month, all stocks are sorted into quintile portfolios based on their lagged market skewness risk measure, $\beta_{\Delta SKEW}$. We record the monthly returns of each portfolio for the subsequent month. Panel A reports the results for the subsample based on the term spread. Panel B reports the results for the subsample based on the expected market risk premium. The t-statistics reported in parentheses are calculated using the heteroskedasticity and autocorrelation consistent covariance standard errors of Newey and West (1987). Statistical significance at the 10%, 5% and 1% levels is indicated by *, **, *** respectively. The sample includes all common stocks traded on the NYSE, AMEX, and Nasdaq from January 1996 to December 2013.

		Quintile portfolio					
Time period	Statistic	1	2	3	4	5	1-5
		Panel A: The term spread					
Good times	*Average return*	2.58***	1.46***	1.38***	1.25***	1.65***	0.93***
		(5.76)	(3.54)	(4.78)	(2.89)	(3.83)	(2.94)
	CAPM alpha	1.46***	0.64**	0.64**	0.41	0.55	0.92***
		(2.90)	(2.12)	(2.20)	(1.56)	(1.20)	(3.01)
	FF3 alpha	1.33***	0.62**	0.64**	0.40	0.36	0.97**
		(3.42)	(2.30)	(2.29)	(1.61)	(1.04)	(2.59)
	Carhart alpha	1.51***	0.74***	0.63**	0.31	0.32	1.18***
		(4.18)	(2.73)	(2.19)	(1.23)	(0.92)	(3.24)
Bad times	*Average return*	0.47	0.46	0.75	0.40	0.09	0.38
		(0.50)	(0.75)	(1.38)	(0.64)	(0.10)	(0.96)
	CAPM alpha	0.09	0.21	0.55**	0.14	-0.26	0.35
		(0.25)	(0.86)	(2.17)	(0.85)	(-0.66)	(0.90)
	FF3 alpha	0.46	0.28	0.52*	0.29	0.19	0.26
		(1.33)	(1.00)	(1.76)	(1.47)	(0.57)	(0.69)
	Carhart alpha	0.46	0.24	0.43	0.26	0.36	0.11
		(1.39)	(0.84)	(1.45)	(1.34)	(0.98)	(0.32)
		Panel B: The expected market risk premium					
Good times	*Average return*	1.24	0.51	0.64	0.11	0.01	1.22***
		(1.21)	(0.96)	(1.32)	(0.19)	(0.01)	(2.66)
	CAPM alpha	1.26**	0.52*	0.65**	0.12	0.03	1.23***
		(2.19)	(1.98)	(2.24)	(0.54)	(0.06)	(2.65)
	FF3 alpha	1.53***	0.66**	0.76**	0.25	0.18	1.35***
		(3.25)	(2.14)	(2.37)	(1.23)	(0.38)	(2.84)
	Carhart alpha	1.66***	0.76***	0.77**	0.24	0.27	1.39***
		(3.81)	(2.85)	(2.36)	(1.08)	(0.60)	(2.78)
Bad times	*Average return*	1.36***	1.24***	1.23***	1.28***	1.15***	0.21
		(3.32)	(3.19)	(3.66)	(4.75)	(3.06)	(0.83)
	CAPM alpha	-0.20	0.04	0.09	-0.04	-0.47*	0.27
		(-0.75)	(0.14)	(0.35)	(-0.25)	(-1.74)	(1.33)
	FF3 alpha	0.09	0.02	-0.02	-0.03	-0.27	0.36*
		(0.23)	(0.07)	(-0.08)	(-0.14)	(-0.78)	(1.79)
	Carhart alpha	0.10	0.02	-0.05	-0.10	-0.25	0.35*
		(0.29)	(0.06)	(-0.18)	(-0.43)	(-0.68)	(1.88)

Table 7
Fama-MacBeth (1973) regressions during good times and bad times

Following Petkova (2006) and Petkova and Zhang (2005), we estimate the term spread and the expected market risk premium to identify "good" and "bad" times. A period with a positive change in the monthly term spread or a period when the expected market risk premium is above the mean are defined as "bad" time, while a period with a negative change in the monthly term spread or a period when the expected market risk premium is below the mean are defined as "good" time. We split the full sample into good times and bad times subsamples. For each month, we estimate Fama and MacBeth (1973) cross-sectional regressions of monthly excess returns on the lagged market skewness beta ($\beta_{\Delta SKEW}$) and the lagged control variables of size ($ln(MV)$), book-to-market ratio ($ln(B/M)$) and momentum (Mom) for the subsamples. $ln(MV)$ is the natural logarithm of the firm's market value of equity at the end of June of year t, $ln(B/M)$ is the natural logarithm of the book-to-market ratio for the fiscal year ending in year $t-1$, and Mom is the cumulative compounded returns over the last 6 months. Panel A reports the estimates for the subsample based on the term spread. Panel B reports the estimates for the subsample based on the expected market risk premium. The t-statistics reported in parentheses are calculated using the heteroskedasticity and autocorrelation consistent covariance standard errors of Newey and West (1987). Statistical significance at the 10%, 5% and 1% levels is indicated by *, **, *** respectively. The sample period is from January 1996 to December 2013.

	Constant	$\beta_{\Delta SKEW}$	*ln(MV)*	*ln(B/M)*	*Mom*
	Panel A: The term spread				
Good times	1.21***	-0.08**			
	(3.21)	(-2.44)			
	2.55	-0.07***	-0.10	-0.10	-0.04
	(1.05)	(-2.64)	(-0.72)	(-0.89)	(-0.06)
Bad times	0.15	0.01			
	(0.25)	(0.23)			
	0.14	-0.01	0.02	0.31	0.08
	(0.11)	(-0.36)	(0.32)	(1.46)	(0.12)
	Panel B: The expected market risk premium				
Good times	0.51	-0.09***			
	(0.97)	(-2.85)			
	2.81**	-0.08***	-0.14**	0.12	-0.26
	(2.26)	(-3.45)	(-2.10)	(0.52)	(-0.30)
Bad times	1.31***	0.01			
	(4.01)	(0.31)			
	0.52	-0.01	0.05	0.08	0.28
	(0.31)	(-0.37)	(0.48)	(0.79)	(0.90)

Table 8
The monthly abnormal returns on two-way sorted portfolios during good times and bad times

This table reports the monthly abnormal returns from the Fama and French (1993) three-factor model for two-way sorted portfolios. We use the term spread to identify "good" and "bad" times. At the end of each good or bad month, we sort stocks into quintiles based on their lagged market skewness risk measure, $\beta_{\Delta SKEW_m}$, and independently sort stocks into three portfolios based on their lagged default likelihood indicator (DLI) and O-score using the 30^{th} and 70^{th} percentiles as the breakpoints. The portfolios are held for the subsequent month. Subscript 1 represents the portfolios comprising stocks with the lowest values of the variables, while subscript 3 represents the portfolios comprising stocks with the highest values of the corresponding variables. The rows labeled 3–1 denote the return difference between the high portfolio and the low portfolio. The column labeled 1-5 denotes the return differences between the bottom and top market skewness risk portfolios. The t-statistics reported in parentheses are calculated using the heteroskedasticity and autocorrelation consistent covariance standard errors of Newey and West (1987). Statistical significance at the 10%, 5% and 1% levels is indicated by *, **, *** respectively. The sample period is from January 1996 to December 2013.

		Quintile portfolio					
		1 (lowest)	2	3	4	5 (highest)	1-5
Good times	DLI_1	1.61***	0.52*	0.62*	0.57***	0.57	1.04***
		(4.45)	(1.78)	(1.94)	(2.71)	(1.52)	(3.27)
	DLI_2	1.18**	0.59*	0.39	0.26	0.08	1.09**
		(2.01)	(1.73)	(1.57)	(0.67)	(0.21)	(2.33)
	DLI_3	0.83	1.20**	0.93	1.17*	0.85	-0.02
		(1.28)	(2.24)	(1.29)	(1.93)	(1.28)	(-0.05)
	3-1	-0.78	0.68	0.31	0.60	0.27	
		(-1.24)	(1.61)	(0.54)	(1.11)	(0.61)	
Bad times	DLI_1	0.98**	0.21	0.56*	0.36**	0.41	0.57
		(2.10)	(0.71)	(1.83)	(2.01)	(1.42)	(1.07)
	DLI_2	0.27	0.26	0.10	-0.04	-0.35	0.62
		(0.58)	(1.11)	(0.40)	(-0.17)	(-0.73)	(1.36)
	DLI_3	0.73	0.18	-0.04	0.65	1.16	-0.43
		(1.10)	(0.65)	(-0.11)	(1.44)	(1.30)	(-0.88)
	3-1	-0.25	-0.03	-0.60	0.30	0.75	
		(-0.49)	(-0.09)	(-1.61)	(0.80)	(0.85)	
Good times	$O\text{-}score_1$	1.45***	0.67*	0.76**	0.53**	-0.06	1.50***
		(3.91)	(1.89)	(2.26)	(2.20)	(-0.14)	(4.38)
	$O\text{-}score_2$	1.58***	0.71***	0.57**	0.13	0.68*	0.90
		(3.12)	(2.67)	(2.60)	(0.45)	(1.71)	(1.45)
	$O\text{-}score_3$	1.64**	1.43***	0.56**	0.63	1.37***	0.27
		(2.41)	(4.32)	(2.40)	(1.66)	(2.65)	(0.42)
	3-1	0.19	0.76*	-0.20	0.10	1.43***	
		(0.34)	(1.87)	(-0.82)	(0.34)	(4.07)	
Bad times	$O\text{-}score_1$	0.67	0.37	0.41	0.20	-0.12	0.79
		(1.45)	(1.08)	(1.13)	(0.97)	(-0.26)	(1.57)
	$O\text{-}score_2$	0.21	0.29	0.57**	0.48*	0.17	0.03
		(0.51)	(1.53)	(2.20)	(1.80)	(0.50)	(0.08)
	$O\text{-}score_3$	1.21***	0.47	1.09	0.76*	1.67**	-0.46
		(2.97)	(1.15)	(1.61)	(1.81)	(2.40)	(-0.58)
	3-1	0.54	0.10	0.68	0.56	1.79***	
		(0.97)	(0.27)	(1.37)	(1.65)	(2.76)	

Table 9

Fama-MacBeth (1973) regressions for the default risk subsamples during good times and bad times

We estimate the term spread to identify "good" and "bad" times. At the end of each good or bad month, we split the full sample into three subsamples based on the stocks' default likelihood indicators (*DLI*) and O-score using the 30th and 70th percentiles as the breakpoints. "*Low*" denotes the subsample that consists of stocks with the lowest value of the variables. "*High*" denotes the subsample that consists of stocks with the highest value of the corresponding variables. "*High-Low*" denotes the difference between the high and low subsamples. For each month, we estimate Fama and MacBeth (1973) cross-sectional regressions of monthly excess returns on the lagged market skewness beta ($\beta_{\Delta SKEW_m}$) and the lagged control variables of size ($ln(MV)$), book-to-market ratio ($ln(B/M)$) and momentum (Mom) for the subsamples. $ln(MV)$ is the natural logarithm of the firm's market value of equity at the end of June of year k, $ln(B/M)$ is the natural logarithm of the book-to-market ratio for the fiscal year ending in year $k-1$, and Mom is the cumulative compounded returns over the last 6 months. The sample period is from January 1996 to December 2013. The t-statistics reported in parentheses are calculated using the heteroskedasticity and autocorrelation consistent covariance standard errors of Newey and West (1987).

	Constant	$\beta_{\Delta SKEW_m}$	*ln(MV)*	*ln(B/M)*	*Mom*	*Constant*	$\beta_{\Delta SKEW_m}$	*ln(MV)*	*ln(B/M)*	*Mom*
	Good times					*Bad times*				
Low DLI	1.05***	-0.11***				0.24	0.02			
	(2.92)	(-2.86)				(0.45)	(0.43)			
	0.81	-0.10***	-0.02	-0.14	0.17	1.11	-0.01	-0.02	0.31	-0.28
	(0.40)	(-2.78)	(-0.13)	(-1.18)	(0.31)	(0.88)	(-0.24)	(-0.36)	(1.65)	(-0.49)
High DLI	1.96**	0.02				0.92	0.02			
	(2.49)	(0.38)				(1.02)	(0.64)			
	1.88	0.01	-0.05	0.15	-0.13	0.83	0.00	-0.05	0.60	-0.46
	(0.65)	(0.15)	(-0.28)	(0.85)	(-0.18)	(0.30)	(0.04)	(-0.23)	(1.69)*	(-0.33)
High-Low	0.91	0.13**				0.68	0.00			
	(1.40)	(2.07)				(1.31)	(-0.02)			
	1.07	0.11*	-0.04	0.29	-0.30	-0.28	0.01	-0.03	0.29	-0.18
	(0.64)	(1.96)	(-0.32)	(1.39)	(-0.46)	(-0.09)	(0.28)	(-0.12)	(1.18)	(-0.20)
Low O-score	1.17***	-0.11***				0.08	0.01			
	(3.36)	(-2.84)				(0.12)	(0.10)			
	0.75	-0.11***	0.00	-0.11	-0.07	-0.71	-0.02	0.05	0.12	0.13
	(0.32)	(-3.24)	(-0.01)	(-0.93)	(-0.09)	(-0.49)	(-0.44)	(0.60)	(0.60)	(0.18)
High O-score	1.51***	-0.02				0.47	0.03			
	(3.30)	(-0.65)				(0.57)	(0.65)			
	3.43*	-0.02	-0.19	-0.02	0.00	-2.07	-0.01	0.19	0.41	0.10
	(1.84)	(-0.62)	(-1.44)	(-0.16)	(-0.01)	(-0.97)	(-0.36)	(1.06)	(1.29)	(0.19)
High-Low	0.34	0.09**				0.39	0.02			
	(0.92)	(2.08)				(1.28)	(0.29)			
	2.69	0.09**	-0.19	0.09	0.07	-1.36	0.01	0.14	0.29	-0.03
	(1.40)	(2.53)	(-1.29)	(0.62)	(0.16)	(-0.50)	(0.20)	(0.71)	(1.14)	(-0.06)

Appendix

A Implied market skewness

We follow Bakshi et al. (2003), Carr and Madan (2001), and Chang et al. (2013) and extract the skewness measure from the option prices as follows:

$$SKEW\left(t,\tau\right)=\frac{E_t^*\left\{\left[R\left(t,\tau\right)-E_t^*\left[R\left(t,\tau\right)\right]\right]^3\right\}}{\left\{E_t^*\left[\left(R\left(t,\tau\right)-E_t^*\left[R\left(t,\tau\right)\right]\right)^2\right]\right\}^{3/2}}, \tag{13}$$

where $R(t,\tau)$ is the τ-period return and defined as $R(t,\tau)=\ln S\left(t+\tau\right)-\ln S\left(t\right)$, $S\left(t\right)$ is the stock price at time t, and $E_t^*[\bullet]$ is the expected value operator under the risk-neutral assumption.

The payoff $H\left[S\right]$ is defined as follows

$$H\left[S\right]=\begin{cases}R\left(t,\tau\right)\\ R^2\left(t,\tau\right)\\ R^3\left(t,\tau\right)\\ R^4\left(t,\tau\right)\end{cases} \tag{14}$$

Following Bakshi and Madan (2000), the payoff function can be spanned by out-of-the-money (OTM) European calls and puts.

$$\begin{aligned}H\left[S\right] &= H\left[\bar{S}\right]+\left(S-\bar{S}\right)H_S\left[\bar{S}\right]+\int_{\bar{S}}^{\infty}H_{SS}\left[K\right]\left(S-K\right)^+dK\\ &\quad+\int_0^{\bar{S}}H_{SS}\left[K\right]\left(K-S\right)^+dK\end{aligned} \tag{15}$$

where $H_S[\bullet]$ and $H_{SS}[\bullet]$ represent the first order and the second order derivative, respectively. The prices of the contracts are obtained by valuing both sides of Equation (15) using the risk-neutral measure:

$$\begin{aligned} E_t^*\left\{e^{-r\tau}H[S]\right\} &= \left(H\left[\bar{S}\right]+\bar{S}H_S\left[\bar{S}\right]\right)e^{-r\tau}+H_S\left[\bar{S}\right]S(t) \\ &\quad+\int_{\bar{S}}^{\infty}H_{SS}[K]\,C(t,\tau;K)\,dK+\int_0^{\bar{S}}H_{SS}[K]\,P(t,\tau;K)\,dK \end{aligned} \tag{16}$$

where $C(t,\tau;K)$, $P(t,\tau;K)$, τ and K are the price of the European call options, the price of the European put options, the maturity of the options and the exercise price of the options, respectively.

Replacing $\bar{S}$ in Equation (16) with $S(t)$, we obtain

$$E_t^*\left\{e^{-r\tau}H[S]\right\}=\int_{S(t)}^{\infty}H_{SS}[K]\,C(t,\tau;K)\,dK+\int_0^{S(t)}H_{SS}[K]\,P(t,\tau;K)\,dK \tag{17}$$

Then, the skewness can be specified as follows:

$$\begin{aligned} SKEW(t,\tau) &= \frac{E_t^*\left\{\left[R(t,\tau)-E_t^*\left[R(t,\tau)\right]\right]^3\right\}}{\left\{E_t^*\left[\left(R(t,\tau)-E_t^*\left[R(t,\tau)\right]\right)^2\right]\right\}^{3/2}} \\ &= \frac{e^{r\tau}W(t,\tau)-3\mu(t,\tau)\,e^{r\tau}V(t,\tau)+2\mu(t,\tau)^3}{\left[e^{r\tau}V(t,\tau)-\mu(t,\tau)^2\right]^{3/2}} \end{aligned} \tag{18}$$

where $V(t,\tau)$, $W(t,\tau)$, $X(t,\tau)$, and $\mu(t,\tau)$ are defined as follows

$$\begin{aligned} V(t,\tau) &= \int_{S(t)}^{\infty}\frac{2\left(1-\ln\left[\frac{K}{S(t)}\right]\right)}{K^2}C(t,\tau;K)\,dK \\ &\quad+\int_0^{S(t)}\frac{2\left(1+\ln\left[\frac{S(t)}{K}\right]\right)}{K^2}P(t,\tau;K)\,dK \end{aligned} \tag{19}$$

$$
\begin{aligned}
W(t,\tau) &= \int_{S(t)}^{\infty} \frac{6\ln\left[\frac{K}{S(t)}\right] - 3\left(\ln\left[\frac{K}{S(t)}\right]\right)^2}{K^2} C(t,\tau;K)\,dK \\
&\quad - \int_{0}^{S(t)} \frac{6\ln\left[\frac{S(t)}{K}\right] + 3\left(\ln\left[\frac{S(t)}{K}\right]\right)^2}{K^2} P(t,\tau;K)\,dK
\end{aligned} \tag{20}
$$

$$
\begin{aligned}
X(t,\tau) &= \int_{S(t)}^{\infty} \frac{12\left(\ln\left[\frac{K}{S(t)}\right]\right)^2 - 4\left(\ln\left[\frac{K}{S(t)}\right]\right)^3}{K^2} C(t,\tau;K)\,dK \\
&\quad + \int_{0}^{S(t)} \frac{12\left(\ln\left[\frac{S(t)}{K}\right]\right)^2 + 4\left(\ln\left[\frac{S(t)}{K}\right]\right)^3}{K^2} P(t,\tau;K)\,dK
\end{aligned} \tag{21}
$$

$$
\mu(t,\tau) \approx e^{r\tau} - 1 - \frac{e^{r\tau}}{2}V(t,\tau) - \frac{e^{r\tau}}{6}W(t,\tau) - \frac{e^{r\tau}}{24}X(t,\tau) \tag{22}
$$

where r is risk free rate.

For a given maturity on each trading day, we employ the cubic spline interpolation to interpolate the implied volatilities between the lowest and the highest available moneyness levels in order to obtain the continuous values of implied volatilities. We use the values of the implied volatility at the boundaries as the implied volatilities that lie outside the range of moneyness. Furthermore, the implied volatilities for the moneyness levels which are between 0.01% and 300% are eliminated. We then use the Black-Scholes options pricing model to calculate the options prices using the available data on implied volatilities. Using Equation (18), (19), (20), (21), and (22), we calculate the implied skewness for each of the maturity dates based on the call and the put prices. Finally, we employ linear interpolation to interpolate between maturities to obtain the implied skewness for S&P 500 index options with one-month maturity.

B The estimation of default likelihood indicator

Let V_t denote the market value of a firm's assets at time t, where V_t is assumed to follow a geometric Brownian motion process. Using the formula for pricing a call option explained in Black and Scholes (1973), the market value of the firm's equity at time t is given by:

$$S_t(V_t, \sigma_V) = N(d_1)V_t - N(d_2)F_t e^{-rT}, \tag{23}$$

where σ_V is the volatility of the market value of the firm's assets, F_t is the book value of the firm's debt at time t, with a maturity date of T, r is the risk-free interest rate, and $N(\bullet)$ denotes the cumulative density function of the standard normal distribution.

The DLI of the firm at time t, denoted $P_{def,t}$, can be computed from the following model:

$$P_{def,t} = P\left(V_{t+T} \leq F_t \mid V_t\right) = N\left(-d_2\right) = N\left[-\frac{ln\left(\frac{V_t}{F_t}\right) + \left(\mu - \frac{\sigma_V^2}{2}\right)T}{\sigma_V\sqrt{T}}\right], \tag{24}$$

where μ is the drift rate of the firm's asset value.

Following Vassalou and Xing (2004), we employ a recursive procedure to estimate the DLI. First, for each stock in the dataset, we estimate the volatility of the firm's equity, σ_E, by calculating the standard deviation of the firm's equity values over the past 12 months. We then treat σ_E as an initial value in an iterative procedure to estimate the volatility of the market value of the firm's assets, σ_V. Specifically, we use the Black-Scholes formula to extract the daily market value of the firm's assets, V_t, for each trading day during the past 12 months by using $S(V_t, \sigma_V)$ as the market value of equity on that day. The standard deviation of the market values of assets, σ_V, is then calculated and subsequently used in the next iteration.

This procedure is repeated until the adjacent values of σ_V from two consecutive iterations converge to a point where the two values differ from each other by less than 0.0001. Although we restrict the maximum number of iterations to 1,000, for most firms, it takes only a few iterations to reach convergence. After we get the market value of assets, V_t, the drift, μ is computed as the mean of the log-returns of V_t. Finally, we calculate the monthly *DLI* for each stock using the estimated values of μ and σ_V together with the values of the firm's debt and assets.[8]

C The estimation of O-score

Following Ohlson (1980), the O-score of a firm is estimated from the following model:

$$\begin{aligned} O-score &= -1.32 - 0.407 SIZE + 6.03 TLTA - 1.43 WCTA + 0.76 CLCA - 1.72 OENEG \\ &\quad -2.37 NITA - 1.83 FUTL + 0.285 INTWO - 0.521 CHIN, \end{aligned} \tag{25}$$

where *SIZE* is the logarithm of total assets (data item *AT*), *TLTA* is the ratio of total liabilities (data item *LT*) to total assets, *WCTA* is the ratio of working capital (data item *WCAP*) to total assets, *CLCA* is the ratio of current liabilities (data item *LCT*) to current assets (data item *ACT*), *OENEG* is a dummy variable which takes the value of one if the firm's total liabilities exceed its total assets and zero otherwise, *NITA* is the ratio of net income (data item *NI*) to total assets, *FUTL* is the ratio of funds from operations (data item *FOPT*) to total liabilities, *INTWO* is a dummy variable taking the value of one if the firm experienced a net loss in the last two years and zero otherwise, and *CHIN* is the ratio of change in net income. We use annual data to compute the O-score for each stock.

[8]Following Vassalou and Xing (2004), the book value of debt is calculated by using "Debt in One Year" plus half of the "Long Term Debt" collected from the Compustat annual files.

D The default probability calculated by the KMV model

The distance to default (DD) calculated from the KMV model is as follow,

$$DD = \frac{V_A - dp}{V_A \sigma_A} \tag{26}$$

where V_A is the market value of a firm's assets, σ_A is the volatility of the firm's assets. dp denotes the default point, which is a value that a firm will default if the firm's asset value falls bellow the point.

To calculate the probabilities of default using the KMV model, we first need to estimate the market value and volatility of a firm's asset. Then calculate the distance to default to determine the level of default risk and finally scaling the distance to default to an actual distribution of default using a default database.

E Firm characteristics

MV: the market value of equity, calculated as share price at the end of June in year t times the number of shares outstanding from the CRSP.

B/M: book-to-market equity, the ratio of the book value of equity to the market value of equity. According to Davis et al. (2000), the book equity (data item BE) is the stockholders' equity (data item SHE), plus balance sheet deferred taxes and investment tax credit (data item $TXDITC$), less book value of preferred stock (in the following order: data item $PSTKRV$ or data item $PSTKL$ or data item $PSTK$). The B/M ratio of year t is the book value of equity for the fiscal year ending in year t-1, divided by the market value of equity at the end of December in year t-1 from CRSP.

$TLTA$: leverage, is the ratio of total liabilities (data item LT) to the book value of total assets.

CF: cash flow to assets ratio, calculated as the ratio of earnings after interest, dividends, and taxes but before depreciation to the book value of total assets ((data item $OIBDP$ - data item $XINT$ - data item TXT - data item DVP - data item DVC) /data item AT).

CH: cash holding ratio, calculated as the ratio of cash and short-term investments (data item CHE) to the book value of total assets.

$Profitability$: return on assets ratio, calculated as the ratio of the operating income before depreciation (data item $OIBDP$) to the book value of total assets.