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Extreme downside risk and expected stock returns

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ABSTRACT

We propose a measure for extreme downside risk (EDR) to investigate whether bearing such a risk is rewarded by higher expected stock returns. By constructing an EDR proxy with the left tail index in the classical generalized extreme value distribution, we document a significantly positive EDR premium in cross-section of stock returns even after controlling for market, size, value, momentum, and liquidity effects. The EDR premium is more prominent among glamor stocks and when high market returns are expected. High-EDR stocks are generally characterized by high idiosyncratic risk, large downside beta, lower coskewness and cokurtosis, and high bankruptcy risk. The EDR premium persists after these characteristics are controlled for. Although Value at Risk (VaR) plays a significant role in explaining the EDR premium, it cannot completely subsume the EDR effect.

1. Introduction

The literature has documented that investors generally shun positions with which they would be subject to catastrophic losses however slight probability these outcomes may carry. Such a "disaster avoidance motive" implies that investors are concerned about extreme negative scenarios and are averse to the risk of sharp price plunges (Menezes et al., 1980). Rietz (1988) and Barro (2006) have shown that rare disasters or tail events are potentially important in explaining the equity premium puzzle. These studies suggest that the potential loss from extremely undesirable returns, denoted as extreme downside risk (hereafter EDR), should be a significant factor in asset pricing. In this study, we focus on downside risk at extreme level and investigate whether EDR can indeed be priced. Specifically, we explore how EDR can be measured, as well as its ability in explaining the cross-sectional differences in expected stock returns.

EDR deserves much attention because extreme losses are encountered far more frequently than predicted by traditionally assumed return distributions (such as normal or lognormal distributions) and the influence of price plunges can be substantial. For example, for all the common stocks traded on NYSE, AMEX, and NASDAQ during July 1963 through June 2009, if the bottom 1% returns for each stock within each year are excluded, the average daily return is more than doubled, jumping from 0.09% to 0.23%. Given these facts, it is natural to expect higher returns from holding stocks with high EDRs. Despite the intuitively appealing idea, there are challenges in examining whether and how EDR is priced in asset returns. One immediate difficulty is finding a good proxy. Though the definition of EDR is conceptually straightforward, it requires estimation of the probability of rare events, sometimes outside the range of available data. That is, "estimates are often required for levels of a process that are much greater than have already been observed" (Coles, 2001).

In this study, we conduct investigation of an EDR measure and its asset pricing implications through an extreme value approach which is specifically designed to describe unusual, extreme events. We draw on the left tail index in the classical generalized extreme value (GEV) distribution as a proxy for EDR and estimate individual stock's EDR from abnormal returns relative to the Carhart (1997) four-factor model. This procedure concentrates exclusively on the far-end left tail of return distribution and captures extreme downside movements of a stock after market, size, value, and momentum factors are controlled for. We observe a significantly positive relation between firm-specific EDR and expected stock returns. This finding remains robust after we control for beta, size, book-to-market (BM) ratio, liquidity, and momentum that are well known to explain cross-sectional variation in stock returns. High-EDR stocks outperform those with low EDRs during 26 out of 36 years between July 1973 and June 2009. The EDR premium

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remains significant across firms of different sizes, and is more prominent in glamor firms. High-EDR stocks experience deeper drops in large market down months and higher expected returns when market returns are expected to be high, reflecting fundamental risks associated with extreme losses.

Our EDR measure incorporates downside and fat tail risks simultaneously. There is a large set of literature that studies risks beyond the Gaussian paradigm. In contrast to the mean–variance framework of Markowitz (1952), which assumes normal distribution and entails equal risks for both positive and negative deviations from the mean, various risk measures have been proposed. Since the safety-first rule introduced by Roy (1952) and developed by Arzac and Bawa (1977) (more recently, by Levy and Levy, 2009), different downside risk measures have been developed, including semi-variance (Markowitz, 1959), gain-confidence limit (Baumol, 1963), lower partial moment (Bawa, 1975; Fishburn, 1977), Value at Risk (VaR), conditional tail expectation, and lower partial standard deviation, among others. Some researchers adopt leptokurtic distributions such as student's *t* (Liesenfeld and Jung, 2000) and those with higher-order moments (Chung et al., 2006) to capture information endowed in the fat tails. The efforts made in modifying traditional measures significantly expand the understanding of risk, although most of the studies concentrate on the downside risk or fat tail risk separately.

In this paper, we focus on downside risk at extreme level for each individual stock. Our EDR measure comes directly from the extreme value theory (EVT) which provides accurate risk assessment of extreme outcomes. In addition, EDR is extracted from four-factor-adjusted returns, thus capturing information not contained in common factors. In essence, EDR is an idiosyncratic measure of extreme downside risk, following the spirit of idiosyncratic skewness in Mitton and Vorkink (2007) and Boyer et al. (2010).[1] This choice of idiosyncratic measure is motivated by Merton (1987) who suggests that in practice it is very difficult to fully diversify if the market is incomplete. Moreover, researches by Ibragimov (2009), Ibragimov and Walden (2007), and Ibragimov et al. (2008) provide theoretical evidence that diversification is not always preferable, especially for extremely heavy-tailed distributions.[2]

Recent empirical asset pricing studies have examined other risk measures from different perspectives. Ang et al. (2006a) show that downside beta helps explain the cross-sectional variation of average stock returns. Harvey and Siddique (2000) document a significant premium for conditional skewness. Moreno and Rodriguez (2009) demonstrate that adding a coskewness factor into mutual fund performance evaluation is economically and statistically significant. Dittmar (2002) introduces the fourth moment (kurtosis) into asset pricing model. All these measures are systematic in that they are based on the relation between individual stock returns and market returns. On idiosyncratic risk, Ang et al. (2006b) find that stock portfolios with high realized idiosyncratic volatility (IV) have low returns in the subsequent month while Guo and Savickas (2010) suggest that IV is a proxy of systematic risk. Mitton and Vorkink (2007) and Boyer et al. (2010) show that expected idiosyncratic skewness and returns are negatively correlated. Bali et al. (2009) measure downside risk with VaR from the empirical distribution of stock returns, and find a positive risk-return tradeoff for several stock market indices. Similarly, Bali et al. (2007) document a positive relation between VaR and expected returns on hedge funds. Our results in this paper reveal that EDR is closely related to many of these risk measures, especially VaR due to its property of reflecting downside and extreme risks. Stocks with higher EDRs normally exhibit higher idiosyncratic standard deviation, skewness, and kurtosis, higher downside beta, more negative coskewness and cokurtosis, and larger firm-specific VaR. We find that the EDR-return relation persists after controlling for all these risk measures. In particular, although VaR can substantially mitigate EDR's impact on expected stock returns, it cannot completely subsume the EDR effect. The EDR premium documented in this paper serves as an additional compensation for holding risky assets, which is beyond the rewards for exposures to standard downside or high-order moment risks.

Because firms with financial distress typically face severe downside risk, we also examine the links between EDR and firm distress measures. We observe a significant relation between EDR and Ohlson's (1980) O-score, which implies that high-EDR stocks carry high likelihood of bankruptcy. Moreover, stocks with higher leverage, lower profitability, lower prices, and larger volatility tend to have higher EDRs. Since these variables are among the firm distress predictors according to Campbell et al. (2008), EDR is also a good indictor of distress risk. Nevertheless, after we control for bankruptcy risk, high-EDR stocks still outperform low-EDR ones, which reinforces EDR's robustness in predicting stock returns.

The remainder of this paper is organized as follows: Section 2 introduces the GEV distribution and presents detailed discussion of sample selection, estimation method of EDR measures, and summary statistics. Section 3 examines the relation between EDR and expected stock returns, as well as the robustness of this relation when controlling for other characteristics variables such as size, BM, momentum, and liquidity. In Section 4, we explore the fundamental risk embedded in EDR by showing that high-EDR stocks suffer from low realized returns during large market down periods, but earn high expected returns when expected market returns are also high. Section 5 examines the relations between EDR and traditional idiosyncratic and downside risks, high-order moment risk measures, bankruptcy and distress risks. We also show the robustness of EDR premium after these variables are controlled for. Section 6 concludes.

2. Extreme value theory and extreme downside risk estimation

2.1. Classical extreme value theory: the generalized extreme value distribution

EVT plays an increasingly important role in describing the probabilistic attributes of extraordinary events. It is specifically designed to assess the shape of the extreme end of a random process and provides the best description of tail behavior among all existing statistical fat tail estimation tools. It plays a role in the sample extrema (maxima or minima) parallel to the role of the central limit theorem in the sample means. Classical EVT depicts the asymptotic distribution of the extrema (or the tail variables) in a GEV distribution with a parameter called tail index, which indicates the thickness of distribution tail. This result is very elegant and robust since it is independent of the original (parent) distribution of the random process. The left tail index becomes an appropriate proxy for EDR because it specifically focuses on the far-end tail of return distribution, providing a more accurate risk assessment of extreme outcomes. A higher EDR is revealed consistently by a higher left tail index. Compared to traditional mean-centered risk measures, EDR avoids potential distribution misspecification or higher-order moments to capture information endowed in the thickness of tails. It also considers the distribution asymmetry of stock returns.

[1] Our approach is different from some of the recent studies which examine impact of rare disasters on the stock market itself. For example, Bianchi (2010) shows that rare events are useful in explaining the cross-section of asset returns by shaping agents' expectations. Estimating expected tails with the EVT, Bollerslev and Todorov (2011) demonstrate that compensation for the fear of rare events can account for a large fraction of the equity and variance risk premia in the S&P 500 index.

[2] Perignon and Smith (2010) empirically show that the abnormally high level of aggregate VaR for US commercial banks is *not* due to a systematic underestimation of the diversification among broad risk categories.