BEYOND TRADİTİONAL BETA: EVALUATİNG DRAWDOWN BETAS İN U.S. MUTUAL FUNDS AND ETFS 2019–2025

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Abstract:

Objective: The primary objective of this study is to estimate and compare four measures of systematic risk – the traditional beta, downside beta, and two recently developed drawdown-based measures, Expected Regret of Drawdown (ERoD) beta and Conditional Drawdown-at-Risk (CDaR) beta – across different confidence levels. In addition, the study seeks to identify mutual funds and exchange-traded funds exhibiting negative $CDaR_{0.99}$ beta values during extreme market downturns and examine their composition across investment categories, thereby providing insights into the types of investment strategies associated with distinct drawdown sensitivities during the largest S&P 500 drawdown events.
Methods: ERoD and CDaR beta are new dynamic portfolio performance risk characteristics measuring portfolio drawdowns. Similar to the standard beta, the drawdown betas relate the expected return of an asset to the expected return of the market but are based on the concept of drawdowns. The analysis is conducted using a sample of the United States-domiciled investment funds over the period from 2019 to 2025.
Findings: The numerical results show that drawdown beta directly measures the performance of U.S. funds during drawdowns. The drawdown betas have negative values and could suggest an adverse behaviour of certain funds during financial crises, while the standard beta is positive. Additionally, the results indicate that mutual funds and exchange-traded funds with negative $CDaR_{0.99}$ beta values are predominantly concentrated in market-protective investment strategies, with trading inverse equity and systematic trend funds accounting for over 58% of the sub-sample. We demonstrate that the drawdown beta is a useful tool in portfolio construction and could indicate the different performances of different funds during uncertainty.

***Keywords*:** CAPM, drawdown beta, crisis risk, U.S. fund industry

INTRODUCTION

The relationship between risk and expected return remains one of the central issues in financial economics. The traditional Capital Asset Pricing Model (CAPM) provides a framework for assessing risk and explaining the relationship between risk exposure and expected returns (Sharpe, 1964; Lintner, 1965; Mossin, 1966). According to the CAPM, investors are compensated only for bearing systematic risk, which cannot be eliminated through diversification and is measured by the beta coefficient. Beta reflects the sensitivity of a stock's returns to movements in the overall market, typically represented by a broad market index. As a result, beta has become a fundamental measure in finance and portfolio management for evaluating the risk characteristics of individual assets.

Although the traditional CAPM relies on beta as the primary determinant of expected returns, empirical evidence suggests that beta alone is insufficient to explain the full variation in asset returns. Conventionally, beta is estimated using historical return data through calculations of variances and covariances. However, this method is complicated by the fact that beta is not constant over time (e.g., Blume, 1975; Ferson and Harvey, 1991; Groenewold and Fraser, 1999). Numerous studies conducted in the United States (Fabozzi and Francis, 1978; Feder-Sempach et al., 2023) have documented the instability of beta estimates. Consequently, beta is often evaluated over relatively short horizons, commonly around five years, as the CAPM generally exhibits stronger explanatory power within shorter sample periods. This instability may reflect a conceptual weakness of the traditional CAPM framework, which treats positive and negative portfolio outcomes symmetrically and does not distinguish between gains and losses. In response to this limitation, alternative risk measures such as drawdown beta have been proposed, offering a potentially more informative assessment of portfolio behavior during periods of market decline.

Several alternative risk measures have been developed to address the limitations of variance-based risk assessment. Among the most recent drawdown-oriented measures are the Conditional Drawdown-at-Risk beta (CDaR beta) introduced by Zabarankin et al. (2014) and the Expected Regret of Drawdown beta (ERoD beta) proposed by Ding and Uryasev (2022). Similar to the traditional beta coefficient, both measures assess the relationship between asset returns and market returns. However, they are founded on the concept of drawdowns, defined as declines in asset value from a previous peak to a subsequent trough. The two measures differ in the way relevant drawdowns are identified. CDaR beta focuses on a specified proportion of the most severe market drawdowns, whereas ERoD beta considers drawdowns exceeding a predetermined threshold.

The primary objective of this study is to compare the traditional betas with the recently developed drawdown-based betas during periods of market stress for U.S. funds, employing the methodologies proposed by Zabarankin et al. (2014) and Ding and Uryasev (2022). To capture the effects of major economic and geopolitical shocks – including the COVID-19 pandemic and Russia's invasion of Ukraine – the analysis is conducted over six years. The drawdown beta framework is applied to evaluate portfolio performance relative to drawdowns in the S&P 500 Index, with comparisons made across different fund characteristics.

Research question: Can drawdown-based beta measures (CDaR beta and ERoD beta) explain mutual fund behavior during periods of market uncertainty more effectively than traditional CAPM measures, such as standard beta and downside beta?
Sub-Research Question: Which investment categories are most represented among mutual funds exhibiting negative $\text{CDaR}_{0.99}$ beta values, indicating adverse sensitivity to the largest 1% of S&P 500 drawdown events?

A notable gap in the mutual fund literature concerns the limited empirical examination of drawdown-based beta measures as alternatives to traditional beta (Riley and Yan, 2022; Kumaran, 2013; Baghdadabad and Glabadanidis, 2013). While traditional beta is widely used to assess systematic risk, its reliance on symmetric volatility may reduce its effectiveness during periods of market stress. Although CDaR beta and ERoD beta are designed to capture downside exposure and recovery characteristics, little evidence exists on whether they better explain mutual fund behavior under conditions of elevated uncertainty. Additionally, we would like to explain which fund categories are most strongly represented among funds exhibiting the strongest adverse behaviour, as measured by negative CDaR Beta values during 1% of the largest drawdowns.

METHODOLOGY

The research sample consists of 18,990 investment funds registered in the United States. The data were obtained from the Center for Research in Security Prices (CRSP) database and cover the period from January 2, 2019, to March 31, 2025. The dataset contains mutual funds and exchange-traded funds (ETFs), including U.S., sector, nontraditional and international equity funds, taxable and municipal bond funds, money market funds, allocation funds, alternative funds, commodities funds, and miscellaneous funds (including leveraged and inverse funds). The dataset includes 1,570 daily observations for each fund, providing a comprehensive panel of daily return data over more than six years. The large sample size and high-frequency observations enable a detailed analysis of fund performance and risk characteristics across different market conditions.

The article compares two drawdown betas – CDaR beta and ERoD beta, and two traditional betas, downside beta and standard beta. The CDaR beta is defined as the average loss of security over a percentage of the largest market drawdown periods, divided by the average market loss during those same periods. The ERoD beta is calculated as the average losses of security during periods when the market experiences a drawdown exceeding a specified threshold ϵ, divided by the average market losses during those same periods (Ding and Uryasev, 2022). The formula for calculating the CDaR beta and ERoD beta for security i is as follows:

$$\hat{\beta}^i_{CDaR,\alpha} = \frac{\sum_{t=1}^{T} q_t\left(w^i_{\tau(t)} - w^i_t\right)}{\sum_{t=1}^{T} q_t\left(w^M_{\tau(t)} - w^M_t\right)},$$

$$\hat{\beta}^i_{ERoD,\epsilon} = \frac{\frac{1}{T}\sum_{t=1}^{T} q^*_t\left(w^i_{\tau(t)} - w^i_t\right)}{\frac{1}{T}\sum_{t=1}^{T} q^*_t\left(w^M_{\tau(t)} - w^M_t\right)},$$

where:
$\boldsymbol{i}$ – index of security $\boldsymbol{i} = \mathbf{1}, \ldots \mathbf{I}$,
$\boldsymbol{t}$ – time, $\boldsymbol{t} = \mathbf{1}, \ldots, \boldsymbol{T}$,
$\boldsymbol{w^i_t}$ – uncompounded cumulative return of asset $\boldsymbol{i}$ at time $\boldsymbol{t}$,
$\boldsymbol{w^M_t}$– uncompounded cumulative return of the market portfolio at time $\boldsymbol{t}$,
$\boldsymbol{d^M_t} = \boldsymbol{w^M_{\tau(t)}} - \boldsymbol{w^M_t}$drawdowns of the market portfolio,
$\boldsymbol{q_t}$ –indicator function, which is equal to $\mathbf{1}/((\mathbf{1}-\boldsymbol{\alpha})\boldsymbol{T})$ if $\boldsymbol{d^M_t}$ is one of the largest $(\mathbf{1}-\boldsymbol{\alpha})\boldsymbol{T}$ drawdowns $\boldsymbol{d^M_1}, \boldsymbol{d^M_2}, \ldots, \boldsymbol{d^M_T}$ of the market portfolio, and 0 otherwise,
$\boldsymbol{q^*_t} = \mathbf{1}(\boldsymbol{d^M_t} \geq \boldsymbol{\epsilon})$ – indicator function, which is equal to 1 for $\boldsymbol{d^M_t} \geq \boldsymbol{\epsilon}$, and 0 otherwise.
$\boldsymbol{\tau(t)} = \mathbf{max}\{\boldsymbol{k} | \mathbf{1} \leq \boldsymbol{k} \leq \boldsymbol{t}, \boldsymbol{w^M_k} = \mathbf{max}_{1 \leq l \leq t}\, \boldsymbol{w^M_l}\}$.

For the CDaR beta, the parameter $\boldsymbol{\alpha} \in [\mathbf{0}, \mathbf{1}]$ controls the percentage of the largest drawdowns included in the calculation. Specifically, $\boldsymbol{\alpha} = \mathbf{0}$ includes all market drawdowns, while $\boldsymbol{\alpha} = \mathbf{1}$ considers only the maximum (i.e, the single largest) market drawdown. For example, the $CDaR_{0.9}$ beta accounts for the largest 10% of drawdowns in the market portfolio. In this study, the CDaR is calculated based on 1, 5, and 10% of the largest drawdowns.

For the ERoD beta, the parameter $\boldsymbol{\epsilon} \in (\mathbf{0}, +\infty)$ determines the magnitude of the market drawdowns to be considered. Ding and Uryasev (2022) proposed a threshold of $\mathbf{0}+$ with $\boldsymbol{\epsilon} = \mathbf{10^{-6}}$ to account for all non-zero drawdowns. In the empirical part of the study, we calculated drawdown betas with the following parameters: the CDaR beta with $\boldsymbol{\alpha} = \mathbf{0.9}, \mathbf{0.95}$ **and** $\mathbf{0.99}$ ($CDaR_{0.9,\ 0.95,\ 0.99}$) and the ERoD beta with a threshold of $\boldsymbol{\epsilon} = \mathbf{10^{-6}}$ (ERoD0+), both based on daily returns[1].

The formula for downside beta is as follows:

$$\hat{\beta}^i_{Downside} = \frac{cov\left(r^i_t, r^M_t | r^M_t < \overline{r^M_t}\right)}{var\left(r^M_t | r^M_t < \overline{r^M_t}\right)},$$

The standard beta is calculated using monthly returns based on Fama and French's (2004) formula:

$$\hat{\beta}^i_{standard} = \frac{cov\left(r^i_t, r^M_t\right)}{var(r^M_t)},$$

where:
i – index of security $i = 1, \ldots \mathrm{I}$,
t – time, $t = 1, \ldots, T$,
r^i_t – return of asset i at time t,
r^M_t– return of the market portfolio at time t.

[1] The drawdown betas are not computed on daily intervals, but the return time series is daily.

It is important to note that the CDaR beta and the ERoD beta capture different drawdown characteristics. The CDaR Beta focuses on unique market conditions, such as the COVID-19 crisis, which are unlikely to recur. In contrast, the ERoD beta takes into account all nonzero drawdowns of S&P500. Thus, the ERoD beta should be treated as an alternative to the CDaR beta.

FINDINGS

To better understand the similarities and differences among the beta measures, we analyse their descriptive statistics (Table 1), correlation structure (Table 2), and number of funds with defined levels of beta parameter (Table 3).

Table 1. Descriptive statistics of betas

Beta	mean	sd	skew	kurt	min	q25	median	q75	max
ERoD beta	0.80	0.58	1.02	9.41	-3.01	0.48	0.74	1.05	8.56
CDaR beta (0.99)	0.73	0.44	-4.79	120.47	-15.83	0.43	0.87	1.01	2.77
CDaR beta (0.95)	0.76	0.45	-1.38	9.80	-5.45	0.51	0.79	1.02	3.25
CDaR beta (0.9)	0.76	0.48	-1.00	7.04	-4.66	0.51	0.76	1.01	3.69
Standard beta	0.69	0.43	-0.94	7.70	-4.19	0.34	0.80	1.00	5.19
Downside beta	0.74	0.45	0.72	21.16	-4.59	0.43	0.81	0.99	10.64

Source: Own calculations.

The descriptive statistics indicate that the average beta values are relatively similar across all measures, ranging from 0.69 to 0.80, suggesting that the typical fund exhibits lower market sensitivity than the benchmark. However, substantial differences emerge in the tails of the distributions.

CDaR beta (0.99) stands out due to its extreme negative skewness (-4.79), exceptionally high kurtosis (120.47), and very low minimum value (-15.83). While most funds have positive beta values, a small group of funds exhibits strongly negative betas, indicating an ability to generate positive returns during the market's most severe drawdown periods. This pattern is much less pronounced for the remaining beta measures.

Overall, the results suggest that CDaR beta (0.99) is particularly effective in identifying funds with strong adverse behaviour that may not be clearly distinguished using standard beta or less restrictive downside-risk measures.

Table 2. Correlation coefficients of betas

Beta	ERoD Beta	CDaR Beta (0.99)	CDaR Beta (0.95)	CDaR Beta (0.9)	Standard Beta	Downside Beta
ERoD beta	1.00	0.56	0.90	0.94	0.60	0.46
CDaR beta (0.99)	0.56	1.00	0.78	0.69	0.94	0.89
CDaR beta (0.95)	0.90	0.78	1.00	0.99	0.76	0.61
CDaR beta (0.9)	0.94	0.69	0.99	1.00	0.68	0.52

Standard beta	0.60	0.94	0.76	0.68	1.00	0.93
Downside beta	0.46	0.89	0.61	0.52	0.93	1.00

Source: Own calculations.

The correlation analysis reveals a generally strong positive relationship among the beta measures, suggesting that they capture similar aspects of fund exposure to market risk. The strongest correlations are observed between CDaR beta (0.95) and CDaR beta (0.90) (0.99), as well as between standard beta and CDaR beta (0.99) (0.94) and downside beta (0.93).

Overall, the results support the view that while the alternative beta measures are closely related, the most restrictive CDaR beta specification captures unique characteristics that are only partially reflected in conventional beta measures. Table 3 depicts the number of U.S. funds with defined beta values, especially negative beta and Figure 1 depicts the histograms.

Table 3. No of funds with defined levels of betas

Beta	**Beta < 0**	**0 ≤ Beta ≤ 1**	**Beta > 1**
CDaR beta (0.9)	608	13365	5017
CDaR beta (0.95)	546	13190	5254
CDaR beta (0.99)	320	13696	4974
ERoD beta	840	12905	5245
Downside beta	261	14212	4517
Standard beta	226	13934	4830

Source: Own calculations.

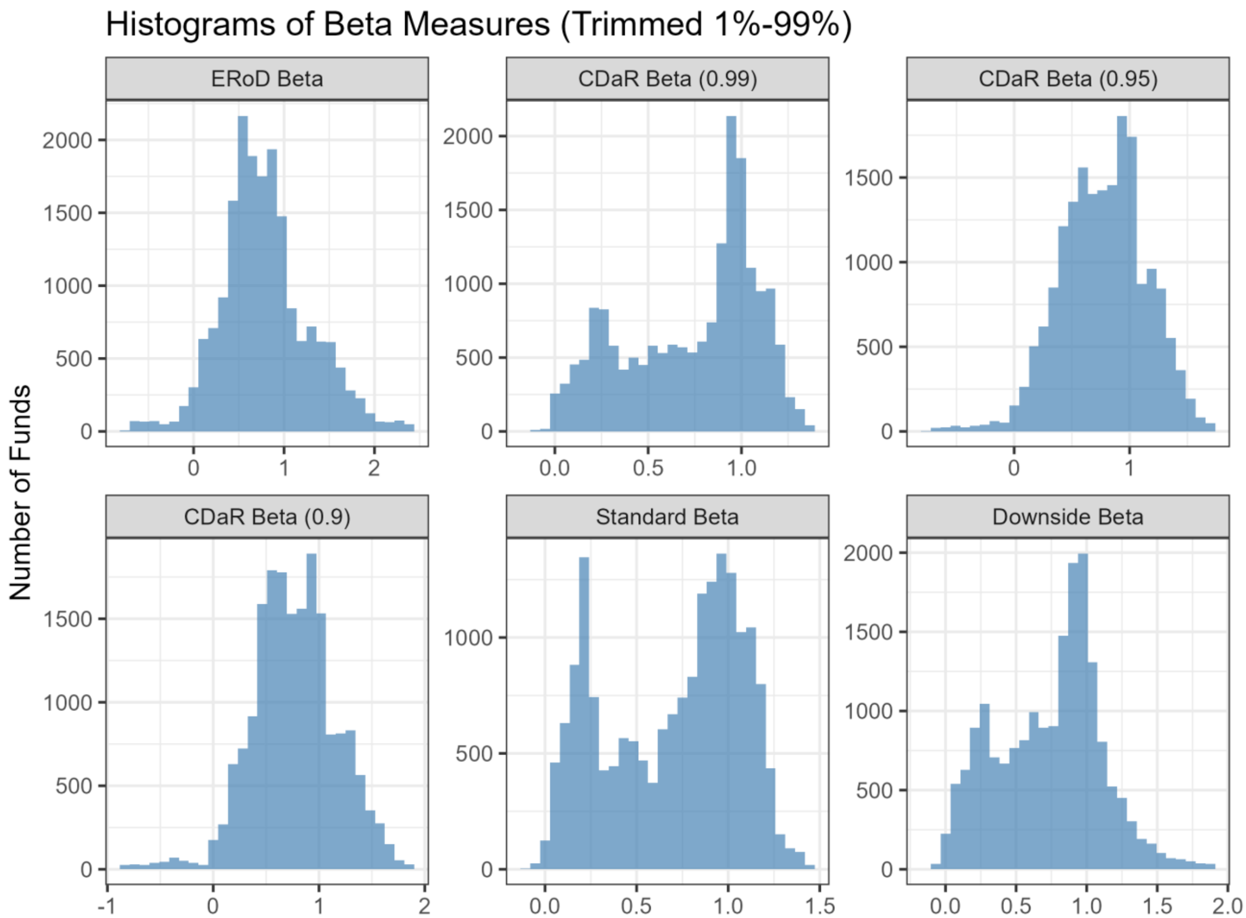

Figure 1. Histogram of beta measures
Source: Own calculations.

The distribution of beta estimates across categories reveals that the majority of observations for all risk measures fall within the range of 0 to 1, indicating moderate exposure to market risk. Standard beta classifies 13,934 observations in this range, while ERoD beta identifies slightly fewer (12,905), suggesting that ERoD beta attributes higher market sensitivity to a larger number of funds. This is reflected in the greater number of observations with Beta > 1 for ERoD Beta (5,245) compared to standard beta (4,830). Similarly, the CDaR beta measures identify between 4,974 and 5,254 observations with beta > 1, depending on the confidence level, exceeding the count produced by the standard beta. Furthermore, ERoD beta generates the highest number of negative beta estimates (840), followed by CDaR beta measures, whereas standard beta produces the fewest negative betas (226). Overall, the drawdown-based measures, particularly ERoD beta and CDaR beta at the 95% confidence level, appear to distinguish a larger proportion of funds as exhibiting either elevated market sensitivity or inverse market exposure, suggesting that they capture aspects of downside risk and fund behavior not fully reflected by the traditional beta measure.

Overall, the similarity in distributions indicates that Downside beta and standard beta provide comparable classifications of fund risk exposure, with a correlation coefficient of 0.93, whereas ERoD beta and the CDaR beta measures tend to identify a larger proportion of funds with either elevated market sensitivity or inverse market exposure. These findings suggest that drawdown-based measures capture additional dimensions of downside risk and fund behavior that may not be fully reflected by traditional variance-based beta measures.

For further analysis, we selected all funds exhibiting negative $CDaR_{0.99}$ beta values, potentially generating profit during market losses. A negative CDaR beta indicates that the fund tended to generate positive returns during periods corresponding to the market's most severe drawdowns, specifically the worst 1% of drawdown observations. Therefore, these funds demonstrated the ability to protect against extreme market downturns and can be considered potential safe-haven investments under highly adverse market conditions. Figure 2 depicts the percentage of funds with negative $CDaR_{0.99}$ beta according to Morningstar investment fund categories.

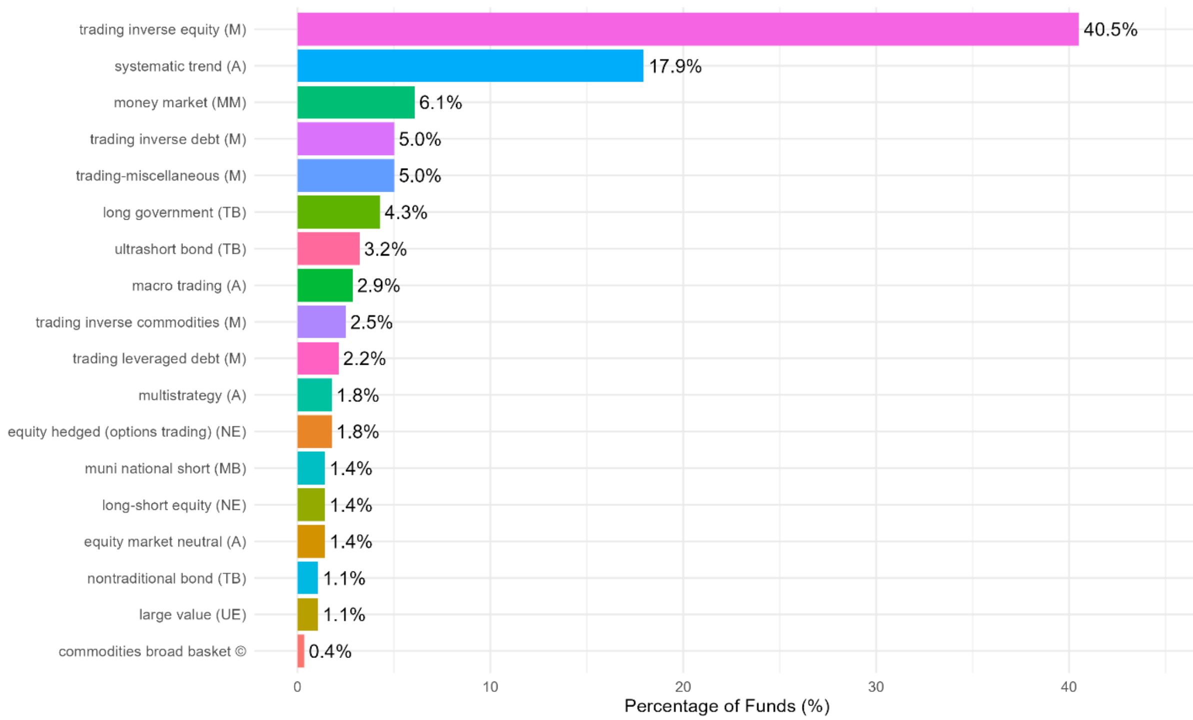

Figure 2. Funds with negative $CDaR_{0.99}$ Beta across specialized investment categories
Source: Own calculations.

According to Figure 2, the composition of mutual funds with negative $CDaR_{0.99}$ beta is highly concentrated in a few categories. Trading inverse equity funds account for the largest share (40.5%), followed by systematic trend strategies (17.9%). Together, these two categories comprise over 58% of all funds in the sample, indicating that funds exhibiting negative sensitivity to extreme downside market risk are predominantly associated with market-protective investment approaches. Other notable categories include money market funds (6.1%), trading inverse debt (5.0%), and trading-miscellaneous (5.0%).

Overall, the results suggest that funds with negative $CDaR_{0.99}$ beta are largely concentrated in defensive, hedging, and alternative investment strategies rather than traditional long-only equity or bond categories. Inverse and leveraged inverse products alone represent more than 50% of the sample, highlighting their ability to provide protection or positive performance during periods of 1% of the largest market drawdowns.

CONCLUSIONS

The findings provide evidence that drawdown-based beta measures, particularly CDaR beta and ERoD beta, offer a different perspective on mutual fund risk exposure compared to traditional CAPM beta. While standard beta and downside beta produced relatively similar classifications of funds, the drawdown-based measures identified a larger number of funds with either elevated market sensitivity (Beta > 1) or negative market exposure. This suggests that CDaR beta and ERoD beta are more sensitive to the downside dynamics and recovery patterns that characterize periods of market uncertainty. As a result, these measures appear to capture dimensions of systematic risk that are not fully reflected by variance-based beta estimates. Therefore, in relation to the research question, the results support the view that drawdown-based beta measures can better explain mutual fund behavior during periods of market stress, as they incorporate the magnitude and persistence of losses experienced by investors. Additionally, the findings reveal a strong concentration of mutual funds with negative $CDaR_{0.99}$ beta values in market-protective strategies, with trading inverse equity and systematic trend funds accounting for almost 58% of the sub-sample.

This study has several limitations that should be considered when interpreting the results. First, although the research sample is large and consists of 18,990 investment funds registered in the United States, the sample is not homogeneous. It includes funds with different investment objectives, asset classes, management styles, and risk profiles, which may influence the estimated beta measures and their relationship with fund behavior.

The results also have important practical implications for investors, fund managers, and financial analysts. Traditional beta remains one of the most widely used measures of market risk; however, it may underestimate risks associated with crisis. By explicitly accounting for drawdowns and recovery dynamics, CDaR beta and ERoD beta can provide a more investor-oriented assessment of risk, particularly for investors concerned with capital preservation during adverse market conditions.

REFERENCES

Baghdadabad, M. T. & Glabadanidis, P. (2013). Evaluation of Malaysian mutual funds in the maximum drawdown. International Journal of Managerial Finance, 9(3), 247-270. https://doi.org/10.1108/IJMF-07-2011-0056

Blume, M. E. (1975). Betas and their regression tendencies. The Journal of Finance, 30(3), 785–795. https://doi.org/10.2307/2326858

Ding, R., & Uryasev, S. (2022). Drawdown beta and portfolio optimization. Quantitative Finance, 1–12. https://doi.org/10.1080/14697688.2022.2037698

Fabozzi, F. J., & Francis, J. C. (1978). Beta as a Random Coefficient. The Journal of Financial and Quantitative Analysis, 13(1), 101–116. https://doi.org/10.2307/2330525

Feder-Sempach E., Szczepocki P., & Dębski W. (2023). What if beta is not stable? Applying the Kalman filter to risk estimates of top US companies over the long time horizon, Bank i Kredyt, Narodowy Bank Polski, vol. 54(1).

Ferson, W. E., & Harvey, C. R. (1991). The Variation of Economic Risk Premiums. Journal of Political Economy, University of Chicago Press, vol. 99(2), 385-415, April.

Groenewold, N., & Fraser, P. (1999). Time-varying estimates of CAPM betas. Mathematics and Computers in Simulation, 48(4–6), 531–539. https://doi.org/10.1016/S0378-4754(99)00033-6

Kumaran, S. (2013). Drawdown Risk in Mutual Funds' Performance. Journal of Finance and Investment Analysis, 2(2), 89-106.

Lintner, J. (1965). The Valuation of Risk Assets and the Selection of Risky Investments in Stock Portfolios and Capital Budgets, Review of Economics and Statistics. 47:1, 13–37.

Mossin, J. (1966). Equilibrium in a capital asset market. Econometrica, 35(4), 768–783. https://doi.org/10.2307/1910098

Riley, T. & Yan, Q (2022). Maximum Drawdown as Predictor of Mutual Fund Performance and Flows. Financial Analysts Journal, 78(4), 59-76. https://doi.org/10.1080/0015198X.2022.2100232

Sharpe, W. F. (1964). Capital asset prices: A theory of market equilibrium under conditions of risk. The Journal of Finance, 19(3), 425–442. https://doi.org/10.1111/j.1540-6261.1964.tb02865.x

Zabarankin, M., Pavlikov, K., & Uryasev, S. (2014). Capital Asset Pricing Model (CAPM) with drawdown measure. European Journal of Operational Research, 234(2), 508–517. https://doi.org/10.1016/j.ejor.2013.03.024