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MEAN-DRAWDOWN RISK BEHAVIOR: DRAWDOWN RISK AND CAPITAL ASSET PRICING

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Abstract. We develop an alternative approach based on mean-drawdown risk behavior versus the mean-variance behavior. We develop two risk measures as the maximum drawdown risk and average drawdown risk to estimate two new betas and then propose two *CAPM*-like models. The data includes a comprehensive universe of more than 11,000 US equity-based mutual funds from first month of 2000 to third month of 2011.

The evidence clearly shows superiority of the maximum and average drawdown betas and their pricing models, the maximum drawdown *CAPM* and the average drawdown *CAPM*, over the traditional beta and *CAPM*, respectively.

Keywords: Mean-maximum drawdown behavior, Mean-average drawdown behavior, Drawdown risk measure, Maximum drawdown beta, Average drawdown beta, Maximum drawdown *CAPM*, Average drawdown *CAPM*.

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JEL Classification: G12, G15.

Introduction

The academics and practitioners have been arguing in the competence of capital asset pricing model (*CAPM*) over the last decades. They have been answering this key question whether beta coefficient is an appropriate risk measure. The majority of these debates concentrate on comparing the ability of this coefficient rather than alternative risk measures to describe the cross section of assets' return (Ang *et al.* 2002; Estrada 2007; Da 2012). However, majority of these debates overlook where beta as a risk measure comes from equilibrium that investors represent in the mean-variance (MV) behavior. In fact, it comes from an equilibrium in which investors maximize a utility function that depends on mean and variance related to the returns of their portfolio.

However, the variance of returns and its standard deviation is an inappropriate risk measure for two reasons: first, it is a desirable risk measure only when the returns have a symmetric distribution. And second, it can be employed as a risk measure only when the distribution of returns is normal. However, both the symmetry and the normality of stock returns are seriously questioned by the empirical evidence on the subject (Chunhachinda *et al.* 1997; Tee 2009; Dichtl, Drobetz 2011).

Against, the drawdown risk measure (hereafter, *DRM*) of returns, which is decomposed to two measures of maximum drawdown risk (hereafter, *M-DRM*) and average drawdown risk (hereafter, *A-DRM*), is a more acceptable measure of risk for several reasons: first, investors logically prefer downside volatility (Stevenson 2001; Galagedera 2007; Fortin, Hlouskova 2011). Second, unlike the downside risk, the *DRM* evaluates the loss from a local maximum to the next local minimum and is intuitively appealing for institutional investors (Hamelink; Hoesli 2003, Kim 2010; Schuhmacher, Eling 2011). Third, the *DRM* is more beneficial than the traditional variance (standard deviation) when the dispersion of returns is asymmetric and just as beneficial when the dispersion is symmetric; accordingly the *DRM* is better measure of risk in comparison with the variance. And fourth, the *DRM* is a measure which the information is generated by three statistics of variance, semi-variance, and skewness, thus, it makes possible to utilize alternative single-factor models to estimate the expected returns.

Moreover, the *DRM* can be utilized to make a replacement behavioral assumption as mean-drawdown behavior (hereafter, *MDB*). As described in Hamelink and Hoesli (2003) and Gilli and Schumann (2009), *MDB* is perfectly correlated to the expected utility and can thus be defended across the same lines utilized by Levy and Markowitz (1979), Markowitz (1991), Eling and Schuhmacher (2007), and Caprin and Lisi (2009).

As main contribution of this study, we propose two alternative risk measures for diversified investors, the *M-DRM* and *A-DRM* beta, and two alternative pricing models based on these two risk measures. We also report the evidence from subclasses of US equity-based mutual funds' management styles, which support from the *M-DRM* and *A-DRM* beta over the traditional beta, and also the pricing models generated by the *M-DRM* (*MD-CAPM*) and the *A-DRM* (*AD-CAPM*) over the *CAPM*.

The rest of the paper is organized as follows. Section 1 describes the theoretical and conceptual framework by explaining two approaches of *MVB* and *CAPM* on one hand, and *MDB* and its relevant pricing models on the other hand. Section 2 discusses and reports the empirical evidence which clearly supports the *M-DRM* and the *A-DRM* risk measures, the *M-DRM* and *A-DRM* beta and their relevant pricing models. Finally, the last section reports some concluding remarks.

1. *MVB* vs. *MDB* Framework

We first explain the *MVB* framework and its relevant pricing model and then explain our proposed approach as *MDB* along its relevant pricing models. Then, we explain how to estimate the *M-DRM* and *A-DRM* betas. Finally, we compare our suggested pricing models with *CAPM*.

1.1. *MVB* and asset pricing

The *MVB* framework explains that an investor's utility (U) is determined by the mean (μ_P) and variance (σ_P) of portfolio returns, where $U = U(\mu_P, \sigma_P)$. Thus, the risk of an asset *i* is assessed by the standard deviation of asset's return (σ_i) as:

$$\sigma_i = \sqrt{E[(R_i - \mu_i)^2]}, \tag{1}$$

where R and μ are the return of asset *i* and mean respectively. However, when asset *i* is just one out of many in portfolio, its risk is assessed by its covariance with respect to the market portfolio as:

$$\sigma_{im} = E[(R_i - \mu_i)(R_m - \mu_m)], \tag{2}$$

where *m* is the market portfolio. A more useful risk measure can be assessed by dividing this statistic by return's standard deviation of asset *i* and the market portfolio, thus we estimate asset *i*'s correlation with respect to the market index as:

$$\rho_{im} = \frac{\sigma_{im}}{\sigma_i . \sigma_m} = \frac{E[(R_i - \mu_i)(R_m - \mu_m)]}{\sqrt{E[(R_i - \mu_i)^2].E[(R_m - \mu_m)^2]}}. \tag{3}$$

Alternatively, the covariance between asset *i* and the market index can be divided by the variance of the market index, thus asset *i*'s beta (β_i) is calculated as:

$$\beta_i = \frac{\sigma_{im}}{\sigma_m^2} = \frac{E[(R_i - \mu_i)(R_m - \mu_m)]}{E[(R_m - \mu_m)^2]}. \tag{4}$$

This measure is widely applied in the CAPM pircing model as:

$$E(R_i) = R_f + \beta_i (R_m - R_f), \tag{5}$$

where $E(R_i)$, R_f, and R_m denote the expected return on asset *i*, the risk-free rate, and the expected return on the market, respectively. Finaly, variance is a risk measure under symmetric condition.

1.2. *MDB* and asset pricing

1.2.1. *M-DRM* framework

In the *MDB* framework, investor's utility is $U = U(\mu_{MP}, \sum_{MP}^2)$, where $\sum_M^2$ denotes the maximum drawdown risk of returns on investor's portfolio. In the *M-DRM* framework, the risk of an asset *i* is measured by asset's downside standard deviation on the loss happened from a local maximum to the next local minimum plus the risk premium as:

$$\textstyle\sum_i = \sqrt{E\{\min[(D_{t-1} + (R_{it} - \mu_{it}), 0)]^2\}}, \tag{6}$$

where D_0 is equal to 0. D_t denotes the maximum loss suffered by an investor from 0 to *t*–1. Eq. (6) is a special case of the semi-deviation with respect to benchmark return $B(\sum_{BMi})$ as:

$$\textstyle\sum_{BMi} = \sqrt{E\{\min[(D_{t-1} + (R_{it} - B), 0)]^2\}}. \tag{7}$$

We denote the *M-DRM* of fund *i* as $\sum_i^M$. In the *M-DRM* framework, the counterpart of fund *i*'s covariance to market portfolio is computed by the *M-DRM* covariance as:

$$\sum_{iM} = E\{\min[(D_{t-1} + (R_{it} - \mu_{it}),0)].\min[(D_{t-1} + (R_{Mt} - \mu_{Mt}),0)]\} . \tag{8}$$

Moreover, this co *M-DRM* is unbounded, but it can also be standardized by dividing it by return's *M-DRM* of fund *i* and market index, hence fund *i*'s *M-DRM* correlation is obtained as:

$$\Theta_{iM} = \frac{\sum_{iM}}{\sum_i \cdot \sum_M} = \frac{E\{\min[(D_{t-1} + (R_{it} - \mu_{it}),0)].\min[(D_{t-1} + (R_{Mt} - \mu_{Mt}),0)]\}}{\sqrt{E\{\min[(D_{t-1} + (R_{it} - \mu_{it}),0)]^2\}.E\{\min[(D_{t-1} + (R_{Mt} - \mu_{Mt}),0)]^2\}}} . \tag{9}$$

The co *M-DRM* is divided by the market return's *M-DRM*, hence *M-DRM* beta is obtained as:

$$\beta_i^{M-DRM} = \frac{\sum_{iM}}{\sum_M^2} = \frac{E\{\min[(D_{t-1} + (R_{it} - \mu_{it}),0)].\min[(D_{t-1} + (R_{Mt} - \mu_{Mt}),0)]\}}{E\{\min[(D_{t-1} + (R_{Mt} - \mu_{Mt}),0)]^2\}} . \tag{10}$$

The *M-DRM* beta computes the covariance between the downside returns made by a combination of maximum loss and market risk premium over the investment period. This beta, which is defined as $\beta_i^{M-DRM} = (\sum_i / \sum_M)\Theta_{iM}$, is described into a *CAPM*-like model in the *M-DRM* form as:

$$E(R_i) = R_f + \beta_i^{M-DRM}.(R_m - R_f). \tag{11}$$

As defined in Eq. of (5) and (11), our model replaces by the *M-DRM* beta.

1.2.2. *A-DRM* framework

In the *MDB* framework, the investor's utility is $U = U(\mu_{AP}, \sum_{AP}^2)$, where $\sum_A^2$ denotes the average drawdown risk of returns on the investor's portfolio. In the *A-DRM* framework, the risk of an asset *i* is assessed by asset's downside standard deviation on the loss happened from a local maximum to the next local minimum plus the risk premium as:

$$\sum_i = \sqrt{E\{\min[(A_{t-1} + (R_{it} - \mu_{it}),0)]^2\}} , \tag{12}$$

where A_0 is equal to 0. A_t denotes the average loss that an investor suffers from *0* to *t*–1. Eq. (12) can be more expressed with respect to any benchmark return $B(\sum_{BAi})$ as:

$$\sum_{BAi} = \sqrt{E\{\min[(A_{t-1} + (R_{it} - B),0)]^2\}} . \tag{13}$$

We denote the *A-DRM* of fund *i* simply as $\sum_i^A$. In the *A-DRM* framework, the counterpart of fund *i*'s covariance to the market portfolio is resulted by its *A-DRM* covariance as:

$$\sum_{iA} = E\{\min[(A_{t-1} + (R_{it} - \mu_{it}),0)].\min[(A_{t-1} + (R_{Mt} - \mu_{Mt}),0)]\} . \tag{14}$$

Moreover, it can also be standardized by dividing it by returns' *A-DRM* of fund *i* and the returns' *A-DRM* of market index, hence fund *i*'s *A-DRM* correlation (Θ_{iA}) is obtained as:

$$\Theta_{iA} = \frac{\sum_{iA}}{\sum_i \cdot \sum_A} = \frac{E\{\min[(A_{t-1} + (R_{it} - \mu_{it}), 0)].\min[(A_{t-1} + (R_{Mt} - \mu_{Mt}), 0)]\}}{\sqrt{E\{\min[(A_{t-1} + (R_{it} - \mu_{it}), 0)]^2\}.E\{\min[(A_{t-1} + (R_{Mt} - \mu_{Mt}), 0)]^2\}}} . \tag{15}$$

The co *A-DRM* can be divided by the market return's *A-DRM*, hence *A-DRM* is obtained as:

$$\beta_i^{A-DRM} = \frac{\sum_{iA}}{\sum_A^2} = \frac{E\{\min[(A_{t-1} + (R_{it} - \mu_{it}), 0)].\min[(A_{t-1} + (R_{Mt} - \mu_{Mt}), 0)]\}}{E\{\min[(A_{t-1} + (R_{Mt} - \mu_{Mt}), 0)]^2\}} . \tag{16}$$

The *A-DRM* beta computes the covariance between the downside returns generated by a combination of average loss and market risk premium over the holding period. This beta, which is defined as $\beta_i^{A-DRM} = (\sum_i / \sum_M)\Theta_{iA}$, is described into a *CAPM*-like model in the *A-DRM* form as:

$$E(R_i) = R_f + \beta_i^{A-DRM}(R_m - R_f) . \tag{17}$$

As defined in Eq. of (5) and (17), our model replaces the *CAPM* beta by the *A-DRM* beta.

1.3. A brief discussion on the *M-DRM* and *A-DRM* beta

The *M-DRM* and *A-DRM* betas given by Eq. (10) and (16) can be estimated in at least three ways: first, through dividing the co *M-DRM* and the co *A-DRM* between fund *i* and the market index given by Eq. (8) and (14). Second, through the *M-DRM* and the *A-DRM* of the market index given by Eq. (6) for *i* = *M* and Eq. (12) for *i* = *A*, which are $\beta_i^{M-DRM} = \sum_{iM}^2 / \sum_M^2$ and $\beta_i^{A-DRM} = \sum_{iA}^2 / \sum_A^2$. Third, through multiplying the ratio of *M-DRM* and *A-DRM* of fund *i* and the market index, the former given by Eq. (6) and (12) and the next given by Eq. (6) for *i* = *M* and Eq. (12) for *i* = *A*, by the *M-DRM* and *A-DRM* correlation between fund *i* and the market index, given by Eq. (9) and (15), which are $\beta_i^{M-DRM} = (\sum_i / \sum_M)\Theta_{iM}$ and $\beta_i^{A-DRM} = (\sum_i / \sum_A)\Theta_{iA}$. Both methods are the same because $\Theta_{iM} = \sum_{iM} / (\sum_i \cdot \sum_M)$ and $\Theta_{iA} = \sum_{iA} / (\sum_i \cdot \sum_A)$; hence $\beta_i^{M-DRM} = \sum_{iM} / \sum_M^2 = \sum_i \cdot \sum_M \cdot \Theta_{iM} / \sum_M^2 = (\sum_i / \sum_M)\Theta_{iM}$ and $\beta_i^{A-DRM} = \sum_{iA} / \sum_A^2 = \sum_i \cdot \sum_A \cdot \Theta_{iA} / \sum_A^2 = (\sum_i / \sum_A)\Theta_{iA}$.

Finally, as another clear difference between the two betas, the *DRM* betas can be computed by regression analysis. Let $y_{mt} = \min[(D_{t-1} + (R_{it} - \mu_{it}), 0)]$, $x_{mt} = \min[(D_{t-1} + (R_{Mt} - \mu_{Mt}), 0)]$, and also μ_{my} and μ_{mx} be the mean of y_t and x_t for the *M-DRM*. In addition, let $y_{At} = \min[(A_{t-1} + (R_{it} - \mu_{it}), 0)]$, $x_{At} = \min[(A_{t-1} + (R_{Mt} - \mu_{Mt}), 0)]$, and also μ_{Ay} and μ_{Ax} be the mean of y_t and x_t for the *A-DRM*. If a regression model be run with y_t as the dependent variable and x_t as the independent variable (that is, $y_t = \lambda_0 + \lambda_1 . x_t + \varepsilon_t$, where ε is an error term and λ_0 and λ_1 are coefficients to be estimated), the estimate of λ_1 would be as:

$$\lambda_1 = \frac{E[(x_t - \mu_x)(y_t - \mu_y)]}{E[(x_t - \mu_x)^2]}. \tag{18}$$

Alternatively, as defined in Eqs (10) and (16), β_i^{M-DRM} and β_i^{A-DRM} can be computed as:

$$\beta_i^{M-DRM} = \frac{E[x_t . y_t]}{E[x_t^2]}; \tag{19}$$

$$\beta_i^{A-DRM} = \frac{E[x_t . y_t]}{E[x_t^2]}. \tag{20}$$

Thus, the best method for estimating β_i^{M-DRM} and β_i^{A-DRM} is to test a linear regression without considering a constant between the independent variable, $x_t = \min[(D_{t-1} + (R_{Mt} - \mu_{Mt}), 0)]$ for the *M-DRM* and $x_t = \min[(A_{t-1} + (R_{Mt} - \mu_{Mt}), 0)]$ for the *A-DRM*, and the dependent variable, $y_t = \min[(D_{t-1} + (R_{it} - \mu_{it}), 0)]$ for the *M-DRM* and $y_t = \min[(A_{t-1} + (R_{it} - \mu_{it}), 0)]$ for the *A-DRM*. They are run by $y_t = \lambda_1 . x_t + \varepsilon_t$, where $\beta_i^{M-DRM} = \lambda_1$ and $\beta_i^{A-DRM} = \lambda_1$.

1.4. A brief discussion on the *DRM* risk framework

The *DRM* was extended by practitioners who did not base their work on theoretical considerations. Most of the literatures on *DRM* were found in journals outside of finance (Dacorogna *et al.* 2001), non-refereed finance journals, and finance journals geared to the investment community (Chekhlov *et al.* 2005). This measure was gradually used in finance literature as a new risk measure (Alexander, Baptista 2006; Eling, Schuhmacher 2007). The drawdown is the loss incurred over the investment period. It is the loss in perceptual from the prior local maximum to the next local minimum of an investment, which is decomposed into maximum *DRM* and average *DRM* (Gilli, Schumann 2009). The *DRM* is the loss suffered when an asset is bought at a local maximum and sold at the next local minimum and or the worst loss that the portfolio suffers over the investment period (Alexander, Baptista 2006). It is the worst return suffered by an investor, e.g. the return of an investor who buys the fund at the highest price and sells it at the lowest price. Institutional investors often capture *DRM* as a risk measure to choose a portfolio. The *A-DRM* also is the average loss suffered over the holding period. It is relevant only if one trades the funds under loss condition (Gilli, Schumann 2009).

The concept of *DRM* was primarily introduced by Grossman and Zhou (1993) and Dacorogna *et al.* (2001). They investigated two risk-adjusted measures for investors with risk-averse preferences in the maximum drawdown framework. Hamelink and Hoesli (2004) studied the role of real estate in a mixed-asset portfolio when the maximum drawdown is used instead of the standard deviation. They showed that the maximum drawdown is one of the most natural risk measures, and such a framework can help reconcile the optimal allocations to real securities by institutional investors. Alexander and Baptista (2006), using a drawdown constraint, provided a characteristic of optimal portfolios in the MV framework. Eling and Schuhmacher (2007) used the maximum *DRM* and compared the Sharpe ratio with the *DRM* measures. Schuhmacher and Eling (2011) asserted that *DRM*s are as well as Sharpe measure and showed that the location and scale condition are sufficient for expected utility to imply the rankings of drawdown measure. However, literature shows that none of the studies use the *DRM* in the pricing models

2. Empirical evidence

We use the monthly data of US equity-based mutual funds' management styles. The data is extracted from the Morningstar database. The research population includes all the funds available in the database. Our sample includes the monthly returns adjusted by dividend for more than 11,000 funds from first month of 2000 to third month of 2011. The monthly return for the 90-day Treasury bills as free risk return and S&P500 as market index are extracted from the DataStream. The statistics for all the funds are reported in Table 1.

2.1. Statistical significance for the total sample

The first step of our analysis consists of calculations over the whole sample. One statistic (MR) reports the average return of each style, and other statistics report the risk measures. Average returns over the whole sample are summarized by mean monthly arithmetic returns; these estimates are reported in Table 1. The risk measures are three for the *MVB* (standard deviation, correlation coefficient and beta) and six for the *MDB* (*DRM*, *A-DRM*, their correlation coefficients, the *DRM* betas). An estimate of these measures is calculated over the whole sample. Moreover, since all the styles display positively skewed distributional attributes, this reinforces the use of the *DRM* models very well.

A correlation matrix containing the six measures and mean returns is displayed in Table 2 where the *DRM* risk measures (*DRM*, *A-DRM* and their betas) outperform the traditional measures (standard deviation and beta). In fact, the *DRM* measures and their betas outperform the standard deviation and beta.

Specifically, the relationship between return and risk can be extracted from our regression analysis. We begin by running a cross-sectional linear regression relating mean returns to each of the four surveying risk measures. More precisely:

$$MR_i = \gamma_0 + \gamma_1 RM_i + u_i, \tag{14}$$

where RM_i and MR_i stand for risk measure and mean return, respectively. γ_0 and γ_1 are coefficients to be estimated, u_i is an error term, and i denotes funds. The results of our six regression models are reported in panels A and B of Table 3. Panel A reports the result of OLS regressions, where two regressions describe the existence of heteroskedasticity. Panel B also reports the results of OLS in which statistical significance is reported by White's heteroskedasticity-consistent covariance matrix. The results in both panels are same except for the standard deviation: six risk measures are significant because of explanatory power. As reported in Table 3, the *DRM* measures outperform two tradi-

Table 1. Summary statistics of monthly fund returns

Management Styles	No. Funds	*MR*	*SD*	ρ	β	*A-DRM*	Θ_{iA}	β^{A-DRM}	*M-DRM*	Θ_{iM}	β^{M-DRM}	Skewness	Kurtosis	Jarque-Bera
Blend	1372	1.7	0.055	0.85	0.01	–0.460	1	0.031	–0.35	1.001	0.03	0.368672	2.804475	3.224728
Contrarian	1114	0.4	0.042	–0.63	–0.011	–0.250	1.14	0.039	–0.39	1.12	0.03	0.360281	2.881137	2.955586
Emerging Markets	1085	0.7	0.005	0.76	0.011	–0.230	1.01	0.031	–0.37	0.98	0.03	0.472575	2.573149	5.960111
Equity Income	781	0.1	0.004	0.82	0.007	–0.226	1.12	0.033	–0.32	1.02	0.02	0.506829	2.931852	5.719815
Geographically Focused	2336	0.18	0.056	0.79	0.009	–0.229	1	0.030	–0.35	1	0.03	0.262591	2.611222	2.366100
Growth	1225	0.21	0.062	0.84	0.01	–0.233	1	0.030	–0.38	1	0.03	0.467777	3.394356	5.712225
Growth and Income	1086	0.012	0.048	0.87	0.008	–0.229	1.15	0.033	–0.33	1.01	0.02	0.356029	2.775811	3.088303
Index Fund	1184	0.13	0.055	0.90	0.01	–0.232	1.17	0.032	–0.34	1.01	0.02	0.452010	3.331096	5.136437
Long-Short	506	0.14	0.059	0.81	0.009	–0.228	1.08	0.031	–0.34	0.99	0.025	0.065085	2.122021	4.365674
Market Neutral	627	0.01	0.017	0.17	0.001	–0.211	1.21	0.032	–0.26	1.09	0.018	0.236594	2.727524	1.652249
Value	421	0.22	0.058	0.72	0.009	–0.342	1.02	0.030	–0.43	1	0.028	0.297322	2.221359	5.319352
Total	11,737													

Notes: MR: the mean return; SD: the standard deviation; ρ : the correlation coefficient; β : the beta; *DRM*: the maximum drawdown risk measure; : the maximum drawdown correlation; β^{M-DRM}: the maximum drawdown beta; *A-DRM*: the average drawdown risk measure; Θ_{iA}: the average drawdown correlation; β^{A-DRM} : the average drawdown beta.

tional measures in terms of their explanatory power. The *DRM* and *A-DRM* measures, in fact, outperform the traditional measures and report higher significant coefficient of 0.35 and 0.37, respectively. Similarly, the *DRM* and *A-DRM* betas explain a substantial 38% and 41% of the variability respectively in mean returns.

Table 2. Correlation matrix of full sample

Measures	*MR*	*SD*	*M-DRM*	*A-DRM*	β	β^{M-DRM}	β^{A-DRM}
MR	1.00						
SD	–0.09	1.00					
M-DRM	0.41	–0.35	1.00				
A-DRM	0.25	–0.52	0.93	1.00			
β	–0.36	0.12	0.02	0.05	1.00		
β^{M-DRM}	–0.13	–0.34	0.66	0.75	0.22	1.00	
β^{A-DRM}	0.20	0.53	–0.32	–0.54	–0.04	–0.50	1.00

Notes: MR: the mean return; SD: the standard deviation; β: the beta; *DRM*: the maximum drawdown risk measure; β^{M-DRM}: the maximum drawdown beta; *A-DRM*: the average drawdown risk measure; β^{A-DRM}: the average drawdown beta.

Table 3. Simple regression analysis upon full sample

$$MR_i = \gamma_0 + \gamma_1 RM_i + u_i,$$

MV	γ_0	t-stat	γ_1	t-stat	R^2	Adj-R^2
Panel A: OLS estimation						
SD	0.019	2.014	–0.592	–2.18	0.09	0.07
β	0.012	2.87	–1.16	–4.77	0.14	0.14
M-DRM	0.22	4.73	0.67	12.38	0.36	0.35
β^{M-DRM}	0.14	3.17	–0.003	–13.15	0.39	0.38
A-DRM	0.31	4.89	0.72	13.01	0.39	0.37
β^{A-DRM}	0.16	3.84	–0.002	–14.21	0.42	0.41
Panel B: heteroskedasticity-consistent estimation						
SD	0.019	2.007	–0.59	–1.65	0.09	0.07
β	0.012	4.04	–1.16	–3.72	0.14	0.14
M-DRM	0.22	5.48	0.67	9.24	0.36	0.35
β^{M-DRM}	0.14	3.08	–0.003	–9.2	0.39	0.38
A-DRM	0.31	4.89	0.72	13.01	0.39	0.37
β^{A-DRM}	0.16	3.84	–0.002	–14.21	0.42	0.41

Notes: MR: the mean return; RM: the risk measure; SD: the standard deviation; β: the beta; *DRM*: the maximum drawdown risk measure; β^{M-DRM}: the maximum drawdown beta; *A-DRM*: the average drawdown risk measure; β^{A-DRM}: the average drawdown beta.

Table 4 displays the results of three multiple regressions: the standard deviation and the *DRM*; the standard deviation and the *A-DRM*; beta and *DRM* beta; beta and *DRM* beta and the four risk measures all together. As shown in the table, when traditional beta and *DRM* beta are considered together, it is only the latter that comes out significant. This result also is similar to *A-DRM* beta. When the four risk measures are considered all together, again *DRM* measures (*DRM*, *A-DRM* and their betas) are only measures that come out significant. In other words, our suggested *DRM* betas outperform beta in terms of their explanatory power. The average R-squared for the two-factor regressions of "beta and *DRM* beta" and "beta and *A-DRM* beta" are 0.43 and 0.48 respectively, which implicate their better significant power. This R-squared for the four-factor regressions, as reported in Panel B of Table 4, are 0.72 and 0.76.

2.2. Statistical significance on management styles

In this section, we consider the management styles and re-assess the significance power of each measure. Note that *DRM* measures describe skewed distributions of returns better than the traditional measures. If all the distributions be symmetric, the *DRM* and the standard deviation would contain same information, and *MDB* would lose most of its appeal as a behavioral model.

Table 5 reports the results of simple regressions splitting the sample into the styles. All the measures perform much better in *DRM*s than in traditional measures. Both of *DRM* measures are clearly significant and explain a better explanatory power. This result reinforces the prior findings reported by Hamelink and Hoesli (2004). The R-square coefficients for *DRM* beta are higher than beta, a range from 0.13 on Emerging Markets to 0.44 on Value. These coefficients for *A-DRM* beta are ranged from 0.13 to 0.45. Inversely, these coefficients for the beta are lower than the *DRM* betas, a range from 0.10 to 0.23 that again implicate the superiority of the *DRM* betas.

Table 4. Multiple regression analysis upon full sample

Panel A: $MR_i = \gamma_0 + \gamma_1 RM_{1i} + \gamma_2 RM_{2i} + v_i$											
RM_1 / RM_2	γ_0	t-stat	γ_1	t-stat	γ_2	t-stat					R^2
$SD / M-DRM$	0.22	4.72	–0.09	–0.36	0.67	12.27					0.36
β / β^{M-DRM}	0.14	3.19	–0.5	–2.88	–0.003	–13.18					0.43
$SD / A-ARM$	0.31	5.01	–0.06	–1.24	0.71	13.19					0.43
β / β^{A-DRM}	0.20	3.89	–0.44	–3.26	–0.002	–14.20					0.48
Panel B: $MR_i = \gamma_0 + \gamma_1 RM_{1i} + \gamma_2 RM_{2i} + \gamma_3 RM_{3i} + \gamma_4 RM_{4i} + v_i$											
$RM_1 / RM_2 / RM_3 / RM_4$	γ_0	t-stat	γ_1	t-stat	γ_2	t-stat	γ_3	t-stat	γ_4	t-stat	R^2
$SD / M-DRM / \beta / \beta^{M-DRM}$	0.25	14.33	–0.1	–0.56	0.44	12.22	–0.24	–1.76	–0.002	–13.3	0.72
$SD / A-DRM / \beta / \beta^{A-DRM}$	0.26	14.83	–0.05	–0.89	0.51	12.90	–0.20	–2.01	–0.001	–13.6	0.76

Notes: MR: the mean return; RM: the risk measure; SD: the standard deviation; β: the beta; *DRM*: the maximum drawdown risk measure; β^{M-DRM}: the maximum drawdown beta; *A-DRM*: the average drawdown risk measure; β^{A-DRM}: the average drawdown beta.

Table 5. Management styles: simple regression analysis

$$MR_i = \gamma_0 + \gamma_1 RM_i + u_i,$$

MV	γ_0	t-stat	γ_1	t-stat	R^2	Adj-R^2
1	2	3	4	5	6	7
			Panel A: Blend			
SD	0.01	1.48	–0.56	–1.62	0.06	0.05
β	0.01	2.72	–1.1	–4.43	0.12	0.12
M-DRM	0.26	3.42	0.81	18.72	0.59	0.58
β^{M-DRM}	0.16	3.46	–0.003	–11.61	0.30	0.29
A-DRM	0.28	4.12	0.92	20.11	0.60	0.59
β^{A-DRM}	0.19	3.92	0.004	–14.52	0.34	0.32
			Panel B: Contrarian			
SD	–0.02	–2.77	0.35	2.86	0.58	0.57
β	–0.02	–3.47	–1.39	–5.11	0.16	0.15
1	2	3	4	5	6	7
M-DRM	0.25	2.17	0.82	30.88	0.77	0.77
β^{M-DRM}	–0.01	–2.39	0.0002	3.72	0.18	0.17
A-DRM	0.27	3.25	0.91	35.14	0.80	0.78
β^{A-DRM}	–0.009	–3.39	0.0041	4.15	0.23	0.21
			Panel C: Emerging Markets			
SD	0.01	1.25	–0.35	–0.97	0.11	0.10
β	0.01	3.03	–1.06	–4.33	0.12	0.11
M-DRM	0.3	4.37	0.85	26.9	0.79	0.79
β^{M-DRM}	0.016	4.07	–0.0002	–4.37	0.13	0.13
A-DRM	0.33	4.56	0.91	28.41	0.80	0.79
β^{A-DRM}	0.023	4.86	–0.0001	–4.89	0.15	0.13
			Panel D: Equity Income			
SD	0.017	2.68	–0.95	–4.02	0.16	0.15
β	0.008	2.29	–1.02	–4.23	0.11	0.11
M-DRM	0.19	2.65	0.73	16.43	0.50	0.49
β^{M-DRM}	0.11	4.09	–0.002	–9.46	0.19	0.18
A-DRM	0.27	3.08	0.79	19.46	0.53	0.51
β^{A-DRM}	0.14	4.62	–0.001	–9.84	0.22	0.20
			Panel E: Geographically Focused (Equity Funds)			
SD	0.01	1.2	–0.56	–1.41	0.11	0.10
β	0.01	2.66	–1.14	–4.83	0.14	0.14

Continue of Table 5

1	2	3	4	5	6	7
M-DRM	0.05	5.11	0.14	5.37	0.17	0.17
β^{M-DRM}	0.06	3.73	–0.001	–4.79	0.16	0.15
A-DRM	0.09	5.89	0.26	6.41	0.19	0.18
β^{A-DRM}	0.11	4.12	–0.0008	–4.89	0.19	0.17
Panel F: Growth						
SD	0.007	0.77	–0.3	–0.85	0.06	0.04
β	0.01	2.91	–1.24	–4.84	0.14	0.14
M-DRM	0.06	5.41	0.15	5.66	0.19	0.18
β^{M-DRM}	0.17	3.29	–0.004	–11.12	0.27	0.26
A-DRM	0.1	5.99	0.19	6.02	0.23	0.23
β^{A-DRM}	0.29	3.89	–0.001	–13.09	0.31	0.29
Panel G: Growth and Income						
SD	0.01	2.09	–0.84	–2.64	0.04	0.04
β	0.008	2.007	–0.96	–3.92	0.11	0.10
1	2	3	4	5	6	7
M-DRM	0.03	3.9	0.102	4.27	0.12	0.11
β^{M-DRM}	0.15	3.43	–0.003	–11.29	0.28	0.27
A-DRM	0.04	3.96	0.16	4.30	0.14	0.12
β^{A-DRM}	0.17	3.62	–0.002	–12.11	0.29	0.28
Panel H: Index Fund (Equity Funds)						
SD	0.01	1.23	–0.52	–1.3	0.06	0.04
β	0.01	2.73	–1.13	–4.71	0.14	0.13
M-DRM	0.04	4.2	0.11	4.46	0.13	0.12
β^{M-DRM}	0.19	2.88	–0.004	–14.42	0.43	0.42
A-DRM	0.05	4.33	0.15	4.75	0.15	0.14
β^{A-DRM}	0.21	2.96	–0.003	–14.76	0.44	0.43
Panel I: Long-Short						
SD	0.01	1.63	–0.44	–1.94	0.08	0.06
β	0.01	3.18	–1.3	–5.3	0.17	0.16
M-DRM	0.04	4.58	0.12	4.8	0.14	0.14
β^{M-DRM}	0.1	4.31	–0.002	–8.18	0.18	0.17
A-DRM	0.03	4.77	0.19	4.91	0.16	0.15
β^{A-DRM}	0.15	4.44	–0.001	–8.58	0.19	0.17

End of Table 5

1	2	3	4	5	6	7
			Panel J: Market Neutral (Equity Funds)			
SD	0.003	2.81	–0.29	–3.43	0.08	0.07
β	0.0005	0.71	–0.7	–2.63	0.24	0.23
M-DRM	0.01	2.72	–1.1	–4.43	0.12	0.12
β^{M-DRM}	0.16	3.46	–0.003	–11.61	0.30	0.29
A-DRM	0.02	2.88	–1.6	–4.81	0.14	0.12
β^{A-DRM}	0.19	3.89	–0.002	–11.89	0.31	0.30
			Panel K: Value			
SD	0.02	1.24	–0.50	–1.2	0.07	0.06
β	0.02	2.75	–1.11	–4.70	0.15	0.14
M-DRM	0.05	4.5	0.12	4.48	0.14	0.13
β^{M-DRM}	0.20	2.98	–0.003	–14.38	0.45	0.44
A-DRM	0.06	4.62	0.15	4.71	0.16	0.15
β^{A-DRM}	0.25	3.03	–0.002	–14.69	0.47	0.45

Notes: MR: the mean return; RM: the risk measure; SD: the standard deviation; β: the beta; *DRM*: the maximum drawdown risk measure; β^{M-DRM}: the maximum drawdown beta; *A-DRM*: the average drawdown risk measure; β^{A-DRM}: the average drawdown beta.

Table 6 reports the results of multiple regressions splitting again the sample in the styles. The results confirm that none of the two traditional risk measures have a better significant explanatory power than the *DRM* measures. The *DRM* is significant when jointly considered with the standard deviation, and the *DRM* beta is significant when jointly considered with the beta. Finally, the *DRM* and its beta are significant when jointly considered with the two other traditional measures in the multi-factor models. Panel A also reports when considering multi-factor models of the beta and the *DRM* betas, five styles of Growth and Income, Index Fund, Long-Short, Market Neutral and Value have larger R-square than other combinational models. This implicates more significant of the *DRM* betas in the styles, a range from 0.26 to 0.68.

2.3. Economic significance: spreads in return and risk

To check for the robustness of our results, we divided all the styles into three equally-weighted portfolios classified by beta, and computed the spreads in mean returns between the riskiest portfolio and the least risky portfolio. Then, we repeated the process by ranking the portfolios made by *DRM* betas and computing again the spread between the riskiest portfolio and the least risky portfolio. By focusing on the joint sample of the styles (Panel A of Table 7), there seems a large difference in the spread of two risk measures of portfolios 1 and 3: the difference between traditional betas is 1.08 and between *DRM* betas is 1.5 and 1.3. Note, however, that the average beta of portfolio 1 (1.08) is larger than the average beta of portfolio 3 (0), in addition the average *DRM*

Table 6. Management styles: multiple regression analysis

Panel A: $MR_i = \gamma_0 + \gamma_1 RM_{1i} + \gamma_2 RM_{2i} + v_i$								
Styles	RM_1 / RM_2	γ_0	t-stat	γ_1	t-stat	γ_2	t-stat	R^2
Blend	$SD / M-DRM$	0.26	3.38	–0.18	–0.78	0.81	18.6	0.59
	β / β^{M-DRM}	0.17	3.43	–0.58	–3.09	–0.003	–11.9	0.34
	$SD / A-ARM$	0.27	3.40	–0.19	–0.88	0.82	18.89	0.60
	β / β^{A-DRM}	0.17	3.66	–0.48	–3.56	–0.002	–12.11	0.40
Contrarian	$SD / M-DRM$	0.25	2.19	0.06	1.22	0.81	29.9	0.77
	β / β^{M-DRM}	–0.02	–4.5	–1.2	–4.74	0.0001	3.08	0.22
	$SD / A-ARM$	0.27	2.34	0.17	2.13	0.89	30.12	0.78
	β / β^{A-DRM}	–0.01	–5.01	–2.1	–4.89	0.0101	3.44	0.33
Emerging Markets	$SD / M-DRM$	0.09	7.04	0.01	0.05	0.24	7.05	0.28
	β / β^{M-DRM}	0.01	3.87	–1.1	–4.42	0.0002	4.91	0.12
	$SD / A-ARM$	0.10	6.21	0.22	0.15	0.31	7.67	0.39
	β / β^{A-DRM}	0.21	3.25	–3.25	–4.88	0.0012	4.98	0.23
Equity Income	$SD / M-DRM$	0.032	3.87	–0.6	–1.81	0.065	2.73	0.11
	β / β^{M-DRM}	0.023	2.63	–0.73	–2.82	–0.0003	–2.07	0.15
	$SD / A-ARM$	0.041	3.94	–0.51	–1.99	0.101	3.36	0.20
	β / β^{A-DRM}	0.29	2.89	–1.24	–3.16	0.01	4.28	0.26
Geographically Focused	$SD / M-DRM$	0.05	4.83	–0.06	–0.19	0.14	5.02	0.17
	β / β^{M-DRM}	0.065	4.007	–0.67	–2.98	–0.001	–4.53	0.21
	$SD / A-ARM$	0.07	4.99	–0.05	–0.26	2.14	5.44	0.31
	β / β^{A-DRM}	0.079	5.16	–0.84	–2.96	–0.021	–4.66	0.28
Growth	$SD / M-DRM$	0.05	4.9	0.39	1.52	0.16	5.89	0.20
	β / β^{M-DRM}	0.03	2.66	–0.86	–3.12	–0.0005	–2.01	0.16
	$SD / A-ARM$	0.07	4.98	0.41	1.59	0.19	5.9	0.21
	β / β^{A-DRM}	0.031	2.69	–0.84	–3.89	–0.0011	–2.66	0.17

Continue of Table 6

Panel A: $MR_i = \gamma_0 + \gamma_1 RM_{1i} + \gamma_2 RM_{2i} + v_i$								
Styles	RM_1 / RM_2	γ_0	t-stat	γ_1	t-stat	γ_2	t-stat	R^2
Growth and Income	SD / $M-DRM$	0.03	4.05	–0.39	–1.17	0.09	3.48	0.12
	β / β^{M-DRM}	0.15	3.42	–0.47	–2.52	–0.003	–11.4	0.31
	SD / $A-ARM$	0.036	4.43	–0.31	–2.22	0.10	3.89	0.16
	β / β^{A-DRM}	0.21	3.29	–0.39	–2.76	–0.001	–13.62	0.39
Inde	SD / $M-DRM$	0.04	3.89	–0.14	–0.44	0.11	4.2	0.13
	β / β^{M-DRM}	0.2	2.85	–0.57	–3.51	–0.003	–14.69	0.48
	SD / $A-ARM$	0.12	4.59	–0.10	–0.53	0.26	4.89	0.13
	β / β^{A-DRM}	0.26	2.90	–0.43	–3.97	–0.002	–15.01	0.50
Long-Short	SD / $M-DRM$	0.04	4.38	–0.03	–0.23	0.12	4.67	0.14
	β / β^{M-DRM}	0.03	3.14	–0.96	–3.4	–0.0005	–2.43	0.20
	SD / $A-ARM$	0.03	4.66	–0.01	–2.02	0.17	4.88	0.26
	β / β^{A-DRM}	0.05	3.98	–0.72	–4.02	0.01	2.66	0.32
Market Neutral (Equity Funds)	SD / $M-DRM$	0.004	2.44	–0.29	–3.44	0.003	3.65	0.18
	β / β^{M-DRM}	0.0002	0.23	–0.73	–2.67	4.34	4.49	0.25
	SD / $A-ARM$	0.02	3.11	–0.10	–3.91	0.021	3.99	0.29
	β / β^{A-DRM}	0.024	2.39	–0.24	–4.99	5.11	4.89	0.43
Value	SD / $M-DRM$	0.04	3.89	–0.14	–3.44	0.13	4.6	0.15
	β / β^{M-DRM}	0.2	2.85	–0.57	–3.51	–0.002	–13.69	0.48
	SD / $A-ARM$	0.08	4.01	–0.12	–3.98	0.18	4.74	0.29
	β / β^{A-DRM}	0.31	3.99	–0.36	–3.87	0.014	12.74	0.68

beta of portfolio 1 (1.3) is larger than the average *DRM* beta of portfolio 3 (0.02) and the average *A-DRM* beta of portfolio 1 (1.5) is larger than the average *A-DRM* beta of portfolio 3 (0.07). In terms of mean returns, the spread between portfolios 1 and 3 when classified by beta is 0.96 a month (0.82 annualized), since the spread between these two portfolios when ranked by *DRM* betas is a bit larger, 1.29 a month (0.91 annualized).

End of Table 6

Panel B: $MR_i = \gamma_0 + \gamma_1 RM_{1i} + \gamma_2 RM_{2i} + \gamma_3 RM_{3i} + \gamma_4 RM_{4i} + v_i$

Styles	RM_1 / RM_2 / RM_3 / RM_4	γ_0	t-stat	γ_1	t-stat	γ_2	t-stat	γ_3	t-stat	γ_4	t-stat	R^2
Blend	$SD / M-DRM / \beta / \beta^{M-DRM}$	0.3	14.56	–0.4	–2.28	0.57	15.87	–0.25	–2.29	–0.002	–11	0.79
	$SD / A-DRM / \beta / \beta^{A-DRM}$	0.35	14.89	–0.37	–2.62	0.66	16.26	–0.26	–2.44	0.012	11.5	0.81
Contrarian	$SD / M-DRM / \beta / \beta^{M-DRM}$	0.24	2.18	–0.03	–0.32	0.79	25.03	–0.29	–1.3	2.27	1.78	0.78
	$SD / A-DRM / \beta / \beta^{A-DRM}$	0.31	2.78	–0.02	–0.66	0.86	26.01	–0.19	–1.79	2.69	1.99	0.80
Emerging Markets	$SD / M-DRM / \beta / \beta^{M-DRM}$	0.32	5.34	–0.03	–0.23	0.83	26.85	–0.22	–2.27	–0.0005	–3.32	0.81
	$SD / A-DRM / \beta / \beta^{A-DRM}$	0.36	5.39	–0.02	–0.34	0.86	27.11	–0.32	–2.59	0.001	3.76	0.84
Equity Income	$SD / M-DRM / \beta / \beta^{M-DRM}$	0.25	10.47	–0.48	–2.75	0.53	14.39	–0.29	–2.5	–0.001	–10.6	0.73
	$SD / A-DRM / \beta / \beta^{A-DRM}$	0.29	11.21	–0.32	–2.91	0.61	15.21	–0.20	–2.66	0.01	8.66	0.77
Geographically Focused	$SD / M-DRM / \beta / \beta^{M-DRM}$	0.28	8.62	–0.07	–0.4	0.65	17.29	–0.3	–2.7	–0.001	–7.39	0.75
	$SD / A-DRM / \beta / \beta^{A-DRM}$	0.32	9.84	–0.04	1.22	0.71	19.04	–0.21	–2.9	–0.001	–7.64	0.76
Growth	$SD / M-DRM / \beta / \beta^{M-DRM}$	0.32	13.68	0.15	0.75	0.61	16.69	–0.23	–1.99	–0.002	–10.2	0.78
	$SD / A-DRM / \beta / \beta^{A-DRM}$	0.40	14.09	0.17	0.79	0.67	17.05	–0.19	–2.07	–0.001	–10.7	0.79
Growth and Income	$SD / M-DRM / \beta / \beta^{M-DRM}$	0.28	12.95	–0.71	–4.47	0.52	15.19	–0.26	–2.45	–0.002	–13.1	0.78
	$SD / A-DRM / \beta / \beta^{A-DRM}$	0.29	12.99	–0.69	–4.61	0.54	15.27	–0.23	–2.55	–0.0012	–13.5	0.79
Inde Fund (Equity Funds)	$SD / M-DRM / \beta / \beta^{M-DRM}$	0.26	13.21	0.03	0.12	0.41	11.39	–0.35	–2.63	–0.002	–13.1	0.71
	$SD / A-DRM / \beta / \beta^{A-DRM}$	0.31	15.12	0.04	0.79	0.49	12.24	–0.31	–2.98	–0.001	–13.1	0.71
Long-Short	$SD / M-DRM / \beta / \beta^{M-DRM}$	0.26	9.14	–0.07	–0.6	0.62	15.3	–0.34	–2.38	–0.001	–6.56	0.73
	$SD / A-DRM / \beta / \beta^{A-DRM}$	0.26	9.14	–0.07	–0.6	0.62	15.3	–0.34	–2.38	0.021	6.84	0.79
Market Neutral (Equity Funds)	$SD / M-DRM / \beta / \beta^{M-DRM}$	0.005	1.88	–0.27	–3.28	0.004	3.66	–0.67	–2.55	0.00001	4.17	0.72
	$SD / A-DRM / \beta / \beta^{A-DRM}$	0.14	2.29	–0.10	–4.33	0.034	3.99	–0.22	–2.97	0.023	4.88	0.78
Value	$SD / M-DRM / \beta / \beta^{M-DRM}$	0.24	12.41	0.03	0.12	0.41	11.39	–0.35	–2.63	–0.002	–13.1	0.71
	$SD / A-DRM / \beta / \beta^{A-DRM}$	0.25	12.86	0.04	0.39	0.46	11.77	–0.29	–2.9	–0.001	–14.2	0.74

Notes: MR: the mean return; RM: the risk measure; SD: the standard deviation; β: the beta; *DRM*: the maximum drawdown risk measure; β^{M-DRM}: the maximum drawdown beta; *A-DRM*: the average drawdown risk measure; β^{A-DRM}: the average drawdown beta.

The return spreads spanned by *DRM* betas are larger than those spanned by beta. Moreover, we obtain the relative spread by dividing the spread in monthly mean returns by the spread in the risk measure, which is 0.88 in the case of portfolios ranked by betas and 1.015 in the case of portfolios ranked by *DRM* betas; that is, mean returns are more sensitive to spreads in *DRM* betas than equal spreads in betas.

Panels B, C, D, E, F, G, I, J, K, and L of Table 7 also show same results so that there seems to be a considerable difference in the spread of two risk measures of portfolios 1 and 3 in the styles. In fact, the average betas of portfolio 1 are larger than the average betas of portfolio 3 and the average *DRM* betas of portfolio 1 are larger than the average *DRM* betas of portfolio 3. Moreover, Panels B, C, D, E, F, G, I, J, K, and L of Table 7 show that return spreads spanned by the *DRM* betas are higher than those spanned by beta. Finally, as evidenced by the relative spreads, mean returns are more sensitive to spreads in the *DRM* betas than equal spreads in beta.

Table 7. Economic significant on management styles

Panel A: All Management Styles					
P1	1.08	1.1	1.5	1.3	1.6
P2	0.62	0.45	1.23	1.09	0.66
P3	0	0.14	0.07	0.02	0.31
Spread P1-P3	1.08	0.96	1.43	1.27	1.29
Annualized spread		0.82			0.91
Relative spread		0.88			1.015
Panel B: Blend					
P1	0.14	–0.09	0.36	0.34	0.35
P2	0.09	0.11	0.26	0.21	0.20
P3	–0.15	0.14	0. 05	0. 01	–0.05
Spread P1-P3	0.29	–0.23	0.31	0.33	0.3
Annualized spread		0.64			0.70
Relative spread		0.79			0.9
Panel C: Contrarian					
P1	1.18	1.01	1.31	1.24	2.1
P2	0.81	0.201	1.06	1.01	0.66
P3	–0.075	–0.21	0.12	0.101	0.15
Spread P1-P3	1.105	0.8	1.19	1.139	1.95
Annualized spread		0.60			0.65
Relative spread		0.72			1.71
Panel D: Emerging Markets					
P1	1.04	0.41	1.14	1.11	0.84
P2	0.99	0.21	1.08	1.01	0.32

Continue of Table 7

P3	–0.064	0.27	0.012	0.002	0.65
Spread P1-P3	0.976	0.14	1.128	1.108	0.19
Annualized spread		0.22			0.26
Relative spread		0.14			0.17
Panel E: Equity Income					
P1	0.56	0.23	0.63	0.58	0.74
P2	0.31	0.24	0.37	0.32	0.27
P3	–0.009	0.34	0.009	0.006	0.03
Spread P1-P3	0.551	–0.11	0.621	0.574	0.71
Annualized spread		0.15			0.38
Relative spread		–0.19			1.23
Panel F: Geographically Focused (Equity Funds)					
P1	0.29	0.034	0.35	0.31	0.22
P2	0.11	0.09	0.28	0.23	0.20
P3	–0.14	0.45	0.09	0.07	0.12
Spread P1-P3	0.15	–0.416	0.26	0.24	0.1
Annualized spread		0.24			0.27
Relative spread		–2.77			0.416
Panel G: Growth					
P1	0.14	1.1	0.19	0.16	1.2
P2	0.07	0.82	0.13	0.10	0.83
P3	0.02	0.22	0.02	0.021	0.1
Spread P1-P3	0.12	0.88	0.14	0.139	1.1
Annualized spread		0.44			0.56
Relative spread		7.16			7.91
Panel H: Growth and Income					
P1	0.11	0.75	0.14	0.12	0.8
P2	0.05	0.24	0.08	0.06	0.31
P3	0.022	0.19	0.03	0.026	0.2
Spread P1-P3	0.088	0.56	0.11	0.094	0.6
Annualized spread		0.55			0.56
Relative spread		6.36			6.38
Panel I: Inde Fund (Equity Funds)					
P1	0.09	0.206	0.15	0.1	0.21
P2	0.01	0.101	0.04	0.03	0.17
P3	–0.004	0.09	0.008	0.004	0.15
Spread P1-P3	0.094	0.116	0.142	0.096	0.06
Annualized spread		0.11			

End of Table 7

Relative spread		0.022			0.625
Panel J: Long-Short					
P1	0.08	0.113	0.15	0.11	0.31
P2	0.03	0.08	0.09	0.06	0.12
P3	–0.014	0.02	0.044	0.09	0.06
Spread P1-P3	0.094	0.093	0.106	0.02	0.25
Annualized spread		0.12			0.14
Relative spread		0.98			12.5
Panel K: Market Neutral (Equity Funds)					
P1	0.15	1.17	0.21	0.18	1.19
P2	0.07	0.77	0.11	0.105	0.98
P3	–0.006	0.64	0.007	0.001	0.51
Spread P1-P3	0.156	0.53	0.203	0.179	0.68
Annualized spread		0.68			0.70
Relative spread		3.39			3.79
Panel L: Value					
P1	0.06	0.41	0.104	0.09	0.52
P2	0.02	0.53	0.038	0.03	0.58
P3	–0.14	0.102	0.016	0.008	0.14
Spread P1-P3	0.34	0.308	0.088	0.082	0.38
Annualized spread		0.37			0.4
Relative spread		0.905			4.63

Notes: Portfolio 1 (P1) is the riskiest portfolio (the largest betas); Portfolio 3 (P3) is the least risky portfolio (the lowest betas); MR: the mean return in percent; β: the beta; β^{M-DRM}: the maximum drawdown beta; β^{A-DRM}: the average drawdown beta. Relative spread is the ratio between the Spread P1–P3 in mean returns and the Spread P1–P3 in the measure.

The second method of robustness check is due to the existence of dead and outlier funds, which imposes bias on the process of our analysis. Thus, we first decompose our sample into two periods of 2000 to 2006 and 2006 to 2011, and then repeat our analysis similar to our previous analysis. In addition, we consider a five-year period from 1995 to 2000 and again run the pooled model as reported in Table 8. In general, the results of these tests are similar to the In-sample period, in which our findings clearly support from the drawdown betas versus the traditional beta.

2.4. Expected returns on fund

As a conclusion at this point, our results detect that, when considering the joint sample of the styles, (1) the *DRM* measures outperform the traditional measures; (2) the best betas that describe the cross section of returns are the *DRM* betas (Table 3); (3) the only measures that significantly describe the cross section of returns, when all risk measures are jointly considered, are the *DRM* measures (Table 4); and (4) mean returns are more sensitive to variations in *DRM* betas than to equal variations in traditional beta (Table 7). (5) the *DRM* betas are the best measure that describes the cross section of returns (Table 5); (6) when the measures considered jointly, none of the two traditional measures significantly describes the cross section of returns, and only two *DRM* measures do (Table 6); and (7) mean returns are more sensitive to variations in *DRM* beta than equal variations in traditional beta.

Table 8. Result of robustness check

1995 to 2000

Panel A1: $MR_i = \gamma_0 + \gamma_1 RM_{1i} + \gamma_2 RM_{2i} + v_i$

RM_1 / RM_2	γ_0	t-stat	γ_1	t-stat	γ_2	t-stat	R^2
$SD / A-DRM$	0.021	5.9	0.018	2.76	10.44	6.52	0.67
$SD / M-DRM$	0.11	7.79	0.12	3.24	0.29	8.11	0.39
β / β^{A-DRM}	0.035	66.4	–2.25	–3.84	–0.043	–78.1	0.76
β / β^{M-DRM}	0.14	8.11	0.15	3.78	0.31	8.92	0.41

Panel B1: $MR_i = \gamma_0 + \gamma_1 RM_{1i} + \gamma_2 RM_{2i} + \gamma_3 RM_{3i} + \gamma_4 RM_{4i} + v_i$

$RM_1 / RM_2 / RM_3 / RM_4$	γ_0	t-stat	γ_1	t-stat	γ_2	t-stat	γ_3	t-stat	γ_4	t-stat	R^2
$SD / A-DRM / \beta / \beta^{A-DRM}$	0.037	71.21	0.011	2.22	10.44	4.73	–1.43	–0.9	–0.04	–74.1	0.74
$SD / M-DRM / \beta / \beta^{M-DRM}$	0.28	10.67	2.26	–2.75	0.77	9.39	–0.29	–2.5	–0.001	–9.89	0.72

2000 to 2006

Panel A2: $MR_i = \gamma_0 + \gamma_1 RM_{1i} + \gamma_2 RM_{2i} + v_i$

RM_1 / RM_2	γ_0	t-stat	γ_1	t-stat	γ_2	t-stat	R^2
$SD / A-DRM$	0.047	3.6	0.014	2.98	9.3	3.24	0.65
$SD / M-DRM$	0.18	7.83	0.10	3.01	0.23	7.21	0.40
β / β^{A-DRM}	0.052	72.4	–5.1	–1.36	–0.021	–89	0.75
β / β^{M-DRM}	0.17	7.04	0.12	3.03	0.39	7.19	0.47

Panel B2: $MR_i = \gamma_0 + \gamma_1 RM_{1i} + \gamma_2 RM_{2i} + \gamma_3 RM_{3i} + \gamma_4 RM_{4i} + v_i$

$RM_1 / RM_2 / RM_3 / RM_4$	γ_0	t-stat	γ_1	t-stat	γ_2	t-stat	γ_3	t-stat	γ_4	t-stat	R^2
$SD / A-DRM / \beta / \beta^{A-DRM}$	0.052	71.03	0.011	2.21	8.14	3.55	–2.14	–1.7	–0.037	–70.9	0.73
$SD / M-DRM / \beta / \beta^{M-DRM}$	0.26	9.14	–0.07	–0.6	0.62	15.3	–0.34	–2.3	–0.001	–6.56	0.73

End of Table 8

2006 to 2011

Panel A3: $MR_i = \gamma_0 + \gamma_1 RM_{1i} + \gamma_2 RM_{2i} + v_i$							
RM_1 / RM_2	γ_0	t-stat	γ_1	t-stat	γ_2	t-stat	R^2
SD / $A-DRM$	0.065	3.22	0.014	4.11	8.53	2.52	0.61
SD / $M-DRM$	0.22	2.85	–0.57	–3.51	–0.002	–13.6	0.48
β / β^{A-DRM}	0.077	84.16	–5.12	–2.25	–0.031	–76.2	0.75
β / β^{M-DRM}	0.18	3.43	–0.58	–3.09	–0.003	–11.9	0.34

Panel B3: $MR_i = \gamma_0 + \gamma_1 RM_{1i} + \gamma_2 RM_{2i} + \gamma_3 RM_{3i} + \gamma_4 RM_{4i} + v_i$											
RM_1 / RM_2 / RM_3 / RM_4	γ_0	t-stat	γ_1	t-stat	γ_2	t-stat	γ_3	t-stat	γ_4	t-stat	R^2
SD / $-DRM$ / β / β^{A-DRM}	0.077	60.14	0.022	2.47	10.22	4.14	–2.44	–1.2	–0.048	–72	0.74
SD / $M-DRM$ / β / β^{M-DRM}	0.29	8.82	–0.06	–0.41	0.55	17.57	–0.31	–2.5	–0.001	–7.05	0.73

Notes: MR: the mean return; RM: the risk measure; SD: the standard deviation; β: the beta; *DRM*: the maximum drawdown risk measure; β^{M-DRM}: the maximum drawdown beta; *A-DRM*: the average drawdown risk measure; β^{A-DRM}: the average drawdown beta.

We turn now to compare the expected returns generated by the *CAPM* given by (5), and the alternative models based on the *DRM* betas (MD-*CAPM*) and (AD-*CAPM*) given by (11) and (17). In both cases, a risk-free rate of 0.20 and a market risk premium of 6% are used. The estimates are reported in Table 9, where we find two interesting findings. First, the average traditional beta is smaller than the *DRM* betas in all the styles. Second, the average expected returns in *DRM*-based *CAPM* models are higher than the *CAPM*.

2.5. A final digression: why do the D*RM* betas work?

The superiority of the *DRM* betas versus beta in describing the cross section of fund returns is a somewhat surprising finding to some. In this section, we justify the plausibility of our empirical results. First, an investor does not like volatility; rather he only likes drawdown volatility. He does not have attention to funds which explain jumps higher than the mean; he has attention to funds which explain frequent and large jumps less than the mean. In fact, investors are not worry about getting the return greater than their minimum acceptable one; rather they are worry about getting the return lower than their minimum acceptable one. Moreover, the superiority of *DRM* betas can be related to the contagion impacts in fund markets. Note that in the MV framework, the suitable risk measure is the beta when markets are integrated, and the standard deviation when markets are segmented. The superiority of the *DRM* betas can thus be described by the fact which markets are more integrated on the *DRM* than the upside risk measure due to the contagion impacts, an interpretation consistent with Galagedera (2007), and Fortin and Hlouskova (2011).

Table 9. Expected returns on funds

Management Styles	$\hat{\beta}$	$\hat{\beta}^{A-DRM}$	$\hat{\beta}^{M-DRM}$	*CAPM*	*AD-CAPM*	*MD-CAPM*
Blend	0.008	0.021	0.012	0.20048	0.20126	0.20072
Contrarian	–0.44	0.042	–0.000004	0.17337	0.20252	0.2
Emerging Markets	0.007597	0.04611	0.040036	0.200456	0.202767	0.202402
Equity Income	0.006765	0.2816	0.27106	0.200406	0.216896	0.216264
Geographically Focused	0.007777	0.43421	0.41377	0.200467	0.226053	0.224826
Growth	0.010236	0.41271	0.39575	0.200614	0.224763	0.223745
Growth and Income	0.534217	0.892411	0.864031	0.232053	0.253545	0.251842
Inde Fund	0.019687	0.24291	0.227907	0.201181	0.214575	0.213674
Long-Short	0.194085	0.44750	0.429199	0.211645	0.22685	0.225752
Market Neutral	0.109139	0.45321	0.429085	0.206548	0.227193	0.225745
Value	0.026644	0.30112	0.283456	0.244359	0.218067	0.261126
All Management Styles	0.107404	0.32498	0.308594	0.206444	0.219499	0.218516

Notes: $\hat{\beta}$: the estimated beta; $\hat{\beta}^{M-DRM}$: the estimated maximum drawdown beta; $\hat{\beta}^{A-DRM}$: the estimated average drawdown beta. Expected returns are estimated by Eq. (5), (11) and (17), a risk-free rate of 0.20 and a market risk premium of 6%.

Conclusion

The traditional beta, *CAPM* and their behavioral model (*MVB*) have been widely used but also extensively debated over the past 40 years. Most of the debates versus beta focus on comparing the ability of this coefficient rather than alternative risk measures to describe the cross section of assets' return. We found that the data on US equity-based mutual funds' management styles support from the *DRM* betas and their relevant pricing models, (MD-*CAPM*) and (AD-*CAPM*), rather than beta and *CAPM*. We generated a parallel between the traditional framework in terms of *MVB*, beta, and *CAPM*, and a replacement framework in terms of the *DRM*; that is, on *MDB*, the *DRM* and *A-DRM* betas, and their pricing models. We proposed some methods to estimate the *DRM* betas and to extend them into pricing models, (MD-*CAPM*) and (AD-*CAPM*). Our findings support from the *DRM* versus the traditional measures and show that mean returns are much more sensitive to spreads in *DRM* betas than equal spreads in beta. Moreover, unlike the *CAPM*, the drawdown *CAPM* plausibly generates a higher expected return.

However, we believe that our suggested measures are able to be replaced with the traditional measures, where financial markets experience a depression. It seems that our suggested measures and models provide a better framework to evaluate portfolio in asymmetric condition.

Finally, we investigate the traditional approach of *MVB*, beta, and *CAPM*, and suggest replacing it with alternative approach of *MDB*, the *DRM* betas, and their relevant pricing models.

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