Reducing Risk through Multifactors: Implied Variance Asymmetry and Implied Beta

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Introduction

Volatility is conventionally calculated as the standard deviation of stock returns. A common drawback of utilizing volatility as a risk measure is that it treats upside gains and downside losses as having the same relative riskiness. Intuitively, investor preferences towards upside or downside risk will differ, thereby generating differences in return patterns across stocks. This can be captured in a convenient measure, namely implied variance asymmetry (IVA), introduced by Huang and Li (2019). IVA captures investors' expectation of future upside variance versus downside variance from option prices.

Another classic source of risk is beta, or systematic risk. Beta's shortfalls as a return predictor are well-documented, notably that low-beta assets tend to provide risk-adjusted returns that are higher than what would be predicted by the Capital Asset Pricing Model (CAPM) (Frazzini and Pederson, 2014). The authors propose a Betting-Against-Beta strategy, which creates a long portfolio of low beta assets, a short portfolio of high beta assets, and leverages to achieve beta-neutrality. OptionMetrics explores this further by introducing the Implied-Bet-Against-Beta (IBAB) strategy (DeSimone et. al, 2023). The authors utilize option implied betas to create this new factor, which generates significant outperformance and risk-adjusted compared to the traditional BAB factor.

These factors, implied beta and (IVA), offer a natural combination, isolating different risk sources such as higher-order moments in up/down semi-variances and systematic risk. Leveraging their risk-neutral analogs, we sort our equity universe based on these factors in this research. In this whitepaper, we derive downward movement solely from option markets and test its return predictability. We utilize OptionMetrics' IvyDB US to construct the factor called Implied Variance Asymmetry, abbreviated as IVA, to capture stock risk-neutral volatility skewness.

In comparison to the standalone high IVA factor, the low beta/high IVA strategy outperforms, yielding annual returns of 12% versus 9.4%. In risk-adjusted terms, the low beta/high IVA strategy provides a Sharpe ratio of 0.85, surpassing the standalone high IVA factor's ratio of 0.55. On the opposite end of the spectrum, the high beta/low IVA portfolio demonstrates incredibly poor performance, with annualized returns of -1.4%.

The observed counterintuitive low returns of low IVA contradict risk-based explanations, given academic evidence suggesting investor aversion to skewness risk, which implies a negative relationship between stock returns and IVA (Chang et. al, 2013). However, more recent research has shown that the positive relationship between IVA and returns in the cross-section of stocks can be attributed to informed trading and information asymmetry or arbitrage constraints to short selling (Huang and Li, 2019 & Stilger et. al, 2017). We also present another potential explanation, considering the unlikely persistence of such outperformance over the life of our sample.

Wang and Yan (2021) document the outperformance of downside volatility scaling strategies compared to conventional total volatility scaled strategies. If IVA is predictive of future realized return skewness, then portfolios constructed on the basis of low risk-neutral downside variance (high IVA) will ultimately have lower realized downside variance. Therefore, high IVA portfolios are subject to less frequent extreme downside losses, resulting in higher annualized and risk-adjusted returns. We confirm this theory by demonstrating larger (less negative) skewness and smaller kurtosis of monthly returns for portfolios conditioned on High IVA.

In the following sections of this paper, we cover our methodology for IVA and beta computations, sample and universe, empirical analysis and conclusion.

Methodology

Among various approaches to calculate upside and downside variance, we implemented the model proposed by Kozhan et. al (2013). The variance can be computed based on OTM put and call option contracts in forward price space as follows:

$$iv_{t,T} = 2\int_{F_t}^{+\infty} \frac{C_{t,T}(K)}{B_{t,T}K^2} dK + 2\int_{0}^{F_t} \frac{P_{t,T}(K)}{B_{t,T}K^2} dK = iv_{t,T}^{u} + iv_{t,T}^{d}$$

Where F_t denotes as forward price at time t, $C_{t,T}(K)$ and $P_{t,T}(K)$ are the time t prices of call and put with strike price K and maturity date T, and $B_{t,T}$ is time t price of the unit bond with maturity date T. We can rewrite the above integral form to discrete form for the number of options available in the market as follows:

$$iv_{t,T}^{u} = 2\sum_{F_t \le K_i} \frac{C_{t,T}(K_i)}{B_{t,T}K_i^2} \Delta I(K_i)$$

$$iv_{t,T}^{d} = 2\sum_{K_i \le F_t} \frac{P_{t,T}(K_i)}{B_{t,T}K_i^2} \Delta I(K_i)$$

With the weight function $\Delta I(K_i)$ defined as:

$$\Delta I(K_i) = \begin{cases} \dfrac{K_{i+1} - K_{i-1}}{2}, 0 \le i \le N (with\ K_{N+1} = 2K_N - K_{N-1}) \\ 0, otherwise \end{cases}$$

On each date t, we linearly interpolate the upside and downside variance to the 30-day horizon.
The implied variance asymmetry (IVA) is defined as the difference between upside and downside variance and normalized by the total variance.

$$IVA = \frac{upside\ variance - downside\ variance}{upside\ variance + downside\ variance}$$

Next, we detail our computation of implied betas. The implied beta calculation follows Buss and Vilkov (2012) methodology, utilizing a semi-parametric formula to extract an implied correlation matrix from the physical (realized) correlation matrix. The implied correlation matrix is calculated as:

$$\rho^{Q}_{ij,t} = \rho^{P}_{ij,t} - \alpha_t(1 - \rho^{P}_{ij,t}),$$

Where $\rho^{P}_{ij,t}$ is the physical correlation under the objective measure, and α_t denotes the parameter calculated as follows:

$$\alpha_t = -\frac{(\sigma^Q_{M,t})^2 - \sum_{i=1}^{N}\sum_{j=1}^{N} w_i w_j \sigma^Q_{i,t}\sigma^Q_{j,t}\rho^P_{ij,t}}{\sum_{i=1}^{N}\sum_{j=1}^{N} w_i w_j \sigma^Q_{i,t}\sigma^Q_{j,t}(1-\rho^P_{ij,t})},$$

Where $i = 1 \ldots$ N are all market index constituents, $\sigma^{Q}_{M,t}$ denotes the implied volatility of the market, w_i are the constituent weights, and $\sigma^{Q}_{i,t}$ denotes the implied volatility of constituent securities.[1]

The option-implied beta $\beta^{Q}_{iM,t}$ of stock is calculated below as:

$$\beta^Q_{iM,t} = \frac{\sigma^Q_{i,t}\sum_{j=1}^{N} w_j \sigma^Q_{j,t}\rho^Q_{ij,t}}{(\sigma^Q_{M,t})^2}$$

Sample and Universe

Our sample spans from January 2007 to December 2022, with the primary aim of this research being to document the portfolio return, comprising securities sorted according to the IVA and implied beta factors. The portfolios undergo a monthly rebalance, aligning with the industry standard and mirroring the SPX timeline.

Before delving into portfolio formation, certain filters are applied during the IVA factor calculation to eliminate noise from illiquid securities. These filters encompass the following criteria:

1) A security must possess more than 2 different strikes for both call and put options on a given date.
2) A security must exhibit more than 2 different expirations for both call and put options on a given date.
3) The security must be a constituent in the SPY universe.
4) The bid and offer prices for an option contract should be greater than 0.
5) Special settlement options are excluded.

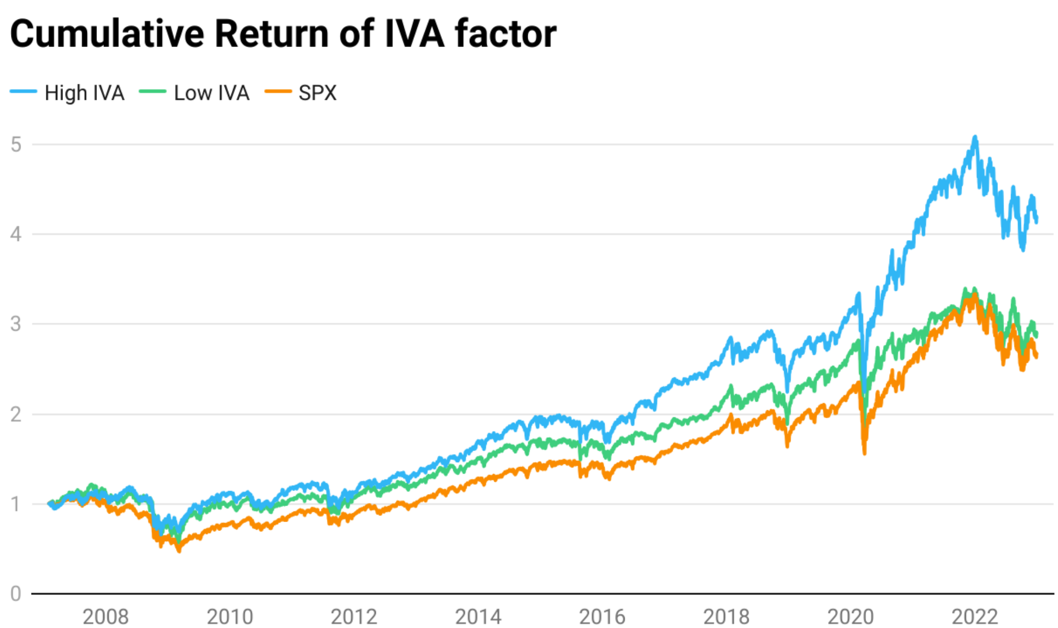
[1] Implied betas are restricted to optionable securities with valid 50-delta, 60-day implied volatilities and a complete one-year return history. Market volatility is also estimated by 50-delta, 60-day volatility on SPY options.

Following the security filtering, a quintile sorting approach based on IVA is implemented. On the last trading day of each month, stocks are partitioned into quintiles based on their IVA levels, with capitalization being weighted within each quintile.

Empirical Analysis

First, we created portfolios based on IVA and conducted back-tests from 2007 to 2022. These portfolios are constructed as long-only portfolios, utilizing stocks within the SPY universe. On the last trading day of each month, we calculate the IVA for our universe and form the top and bottom portfolios for the next month, selecting the top and bottom 20% of securities sorted by IVA.

Figure 1



SPX universe, monthly rebalanced portfolio

Source: OptionMetrics • Created with Datawrapper

Table 1

Summary Statistics

Data starts from January 2007 to December 2022

	High IVA (Top quintile)	Low IVA (Low quintile)
Annualized Returns	0.0945	0.0694
Annualized Volatility	0.1650	0.1723
Sharpe Ratio	0.5580	0.4057
Sortino Ratio	0.8160	0.5896
5 Factor Alpha	−0.0008	−0.0098

Portfolios rebalanced monthly based on IVA

Source: OptionMetrics • Created with Datawrapper

The above show the cumulative return of $1 invested in portfolios created from the top and bottom quintile. Aligning with previous research, higher IVA stocks have higher annualized returns. The top portfolio has a 0.55 Sharpe Ratio and 81% Sortino Ratio[2]. While the bottom IVA portfolio has lower returns, it is comparable to returns on the broad market benchmark of SPX. In summation, the outperformance of high IVA compared to low IVA remains marginal in risk-adjusted terms, as high IVA does not generate positive alpha.

Given that beta and semi-variance isolate different sources of risk, we are keen to determine if we can enhance our risk-adjusted performance by combining these in our portfolio formation approach. We create 5x5 value-weighted portfolios using a conditional sorting mechanism. Initially, stocks are divided into quintiles based on the 30-day implied beta from OptionMetrics' IvyDB Beta. Then, within each implied beta portfolio, the securities are further partitioned by IVA. Each portfolio contains an average of approximately 20 securities during each rebalance period.

Table 2 presents descriptive statistics for the monthly returns of the top/bottom quintiles of the beta portfolio, which are conditionally sorted by IVA. The Low Beta/High IVA portfolio exhibits the highest average monthly returns at 1.1%, surpassing the 0.6% monthly returns of the Low Beta/Low IVA portfolio. Furthermore, when comparing Low Beta/High IVA to Low Beta/Low IVA, it reveals higher skewness (-0.41 vs. -0.46) and lower kurtosis (0.35 vs. 0.85).

Among the high beta portfolios, High Beta/High IVA demonstrates superior average returns compared to High Beta/Low IVA. Once again, conditioning on the high IVA quintiles results in larger positive skewness (0.14) and less kurtosis (3.02 vs. 3.62). Our summary results indicate that using IVA as a sorting statistic diminishes extreme portfolio returns. Next, we provide historical back tests and portfolio performance.

[2] Sortino Ratio = Excess Return / Standard Deviation of Negative Return

Table 2

Descriptive Statistics of Monthly Portfolio Returns for Beta/IVA factors

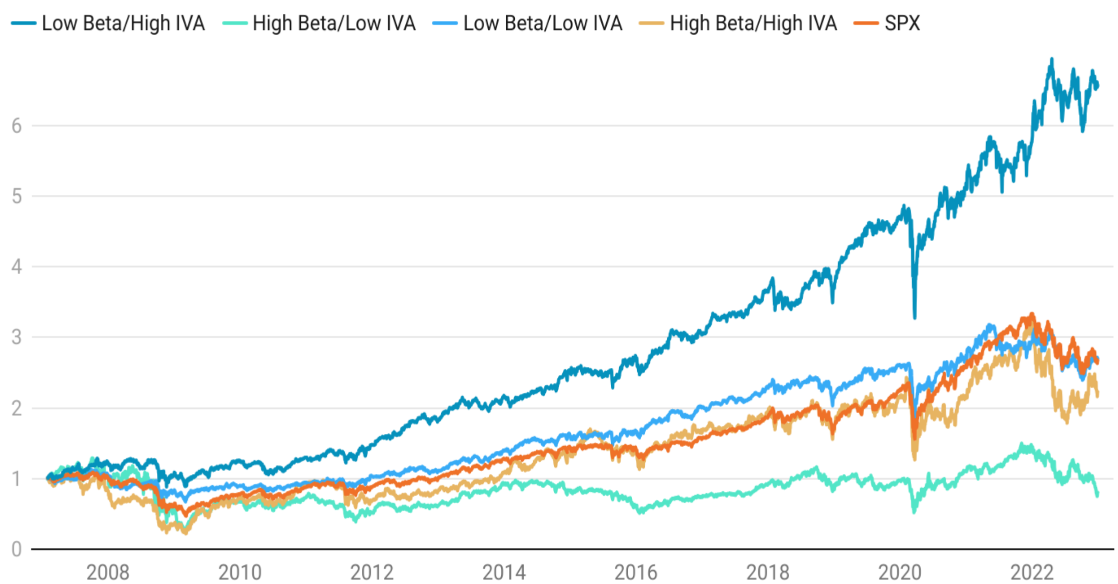
Data starts from January 2007 to December 2022

	Low Beta/High IVA	High Beta/Low IVA	Low Beta/Low IVA	High Beta/High IVA	SPX
Count	191	191	191	191	191
Mean	0.0107	0.0028	0.0060	0.0086	0.0062
Median	0.0124	0.0004	0.0105	0.0151	0.0122
Standard Deviation	0.0394	0.0888	0.0398	0.0938	0.0462
Kurtosis	0.3496	3.6205	0.8473	3.0156	0.9675
Skewness	-0.4134	0.0554	-0.4609	0.1389	-0.5775
Minimum	-0.1004	-0.3859	-0.1218	-0.3178	-0.1694
Maximum	0.1042	0.3448	0.1150	0.4124	0.1268

Source: OptionMetrics • Created with Datawrapper

Figure 2

Cumulative Return of Implied Beta and IVA factors



SPX Universe, Monthly Rebalanced Portfolio

Source: OptionMetrics • Created with Datawrapper

Table 3

Summary Statistics

Data starts from January 2007 to December 2022

	Low Beta/High IVA	Low Beta/Low IVA	High Beta/High IVA	High Beta/Low IVA
Annualized Return	0.1260	0.0646	0.0519	−0.0138
Annualized Volatility	0.1366	0.1377	0.3248	0.3075
Sharpe Ratio	0.8521	0.4360	0.2816	0.0717
Sortino Ratio	1.2327	0.6259	0.4079	0.1007
5 Factor Alpha	0.0548	−0.0029	−0.0372	−0.0664

Source: OptionMetrics • Created with Datawrapper

The second set of graphs depicts the results of these combined factors for the top and bottom quintiles. Based on our findings, the Low Beta/High IVA factor demonstrates superior performance across all portfolio types, including the benchmark. Furthermore, it significantly enhances the single-factor IVA approach. The Low Beta/High IVA portfolio exhibits a 12.6% annualized return, accompanied by a substantial annualized alpha of 0.05[3]. Notably, this strategy yields a dominant Sortino Ratio of 1.23 in comparison to other factor combinations. This outcome aligns with the intuitive nature of the IVA factor's construction; if IVA is indicative of future skewness, then High IVA securities should display lower realized downside standard deviations and larger Sortino values.

Contrastingly, the High Beta/Low IVA factor displays dismal performance, showcasing negative annualized returns of -1.4%, a Sharpe of 0.07, and a Sortino of 0.10. A low Sortino ratio implies relatively higher downside deviations.

In summary, this multifactor approach enhances factor returns by mitigating two distinct sources of risk—market and downside (skewness) risk, as evidenced by higher Sharpe and Sortino ratios.

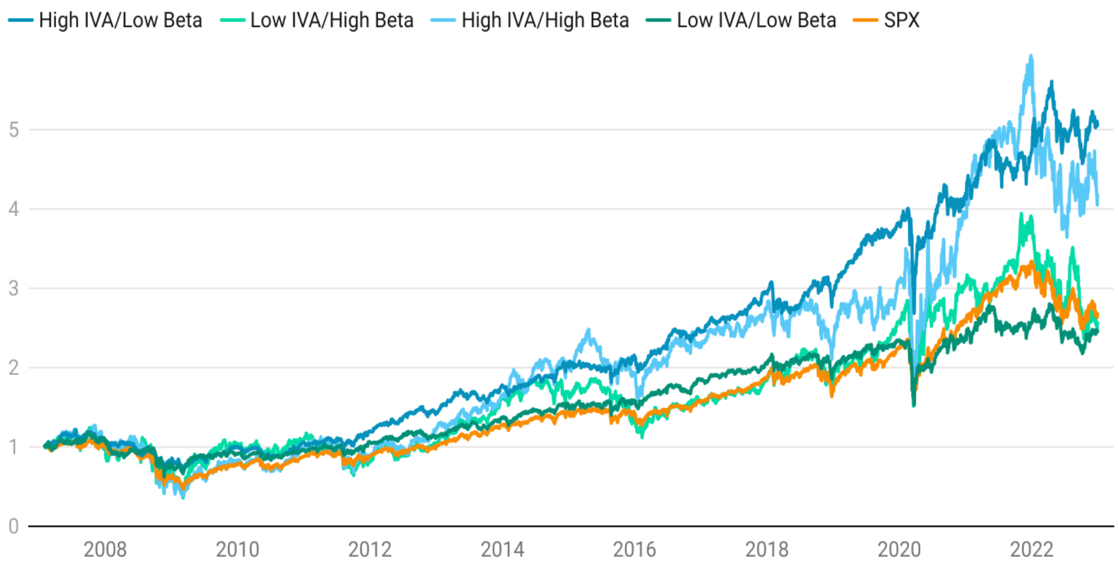
To ensure the robustness of our results, we invert the sorting order by partitioning on IVA and subsequently conditionally sorting on implied beta. The portfolio results are presented in the charts and tables below. The high IVA/low Beta portfolio boasts an annualized return of 10.7% and an annualized alpha of 0.04[4], producing results similar to the Low Beta/High Beta portfolio. Conversely, the high IVA/High Beta portfolio yields a similar annualized return, but the strategy's volatility doubles, leading to a depression in the Sharpe and Sortino Ratios.

[3] Significant at 5% level

[4] Significant at 10% level

Figure 3

Cumulative Return of IVA factor and Implied Beta



SPX Universe, Monthly Rebalanced Portfolio

Source: OptionMetrics • Created with Datawrapper

Table 4

Summary Statistics

Data starts from January 2007 to December 2022

	High IVA/Low Beta	Low IVA/High Beta	High IVA/High Beta	Low IVA/Low Beta
Annualized Return	0.1077	0.0610	0.0943	0.0583
Annualized Volatility	0.1378	0.2794	0.2902	0.1424
Sharpe Ratio	0.7257	0.3051	0.4161	0.3842
Sortino Ratio	1.0493	0.4951	0.6052	0.5575
5 Factor Alpha	0.0389	−0.0090	−0.0013	−0.0065

Source: OptionMetrics • Created with Datawrapper

Within the Low IVA portfolios, we observe weaker annualized returns and higher volatility for the high beta portfolio. Consequently, our inverse sorts consistently support the finding that combining these factors improves returns and reduces volatility compared to their standalone counterparts.

Conclusion

In conclusion, our research explores the integration of implied variance asymmetry (IVA) and implied beta as factors in portfolio formation, aiming to enhance risk-adjusted returns. Traditional measures like volatility, are scrutinized for their limitations in capturing investor preferences towards downside losses. Implied variance asymmetry, introduced by Huang and Li (2017), addresses this by offering a measure that considers higher-order moments derived from up/down implied semi-variances in option prices.

The study delves into the Implied-Beta-Against-Beta (IBAB) strategy, which leverages option-implied betas. The combination of IVA and implied beta factors yields a multifactor approach that mitigates both systematic and downside risk, resulting in superior risk-adjusted returns.

The Low Beta/High IVA strategy outperforms, achieving annual returns of 12% compared to 9.4% for the standalone high IVA factor. The risk-adjusted performance is notable, with a Sharpe Ratio of 0.85 for the low beta/high IVA strategy, surpassing the standalone high IVA factor's ratio of 0.55. On the contrary, the high beta/low IVA portfolio exhibits poor performance, with negative annualized returns of -1.4%. Quintile sorting based on IVA levels and conditional sorting on implied beta further validates the effectiveness of the multifactor approach.

The relatively higher observed returns of High IVA portfolios are attributed to a reduction of downside volatility through more positive skewness and less frequent extreme losses relative to low IVA portfolios, which is supported by larger Sortino Ratios.

In summary, the integration of implied variance asymmetry and implied beta in portfolio formation offers a promising avenue for investors seeking enhancements on traditional Betting-Against-Beta or low volatility strategies.

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