FIN-405 Investments Project

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I. Introduction

Portfolio optimization and risk management are essential for achieving superior investment performance. This assignment applies various advanced strategies, including Betting Against Beta (BAB), Momentum, Idiosyncratic Volatility (IV), Equal-Weighted (EW) returns, Risk Parity (RP), and Mean-Variance Efficient (MVE) portfolios, using data from Wharton Research Data Services (WRDS). By calculating rolling betas, constructing strategy portfolios, and evaluating performance through mean returns, standard deviations, and Sharpe ratios, we aim to manage risk and maximize returns. This study demonstrates the importance of diversification and different weighting schemes in enhancing portfolio performance and offers practical insights for financial practitioners.

II. Betting against Beta Strategy (BaB)

A. Time-Varying Beta Estimation

To compute the time-varying market $\beta_{t,n}$ for each stock, we perform monthly rolling 5-year regressions of stock-specific excess returns on the excess market return. We require at least 36 months of observations for each stock and winsorize the beta at the 5th and 95th percentiles to mitigate the impact of outliers.

B. Portfolio Construction and Performance Analysis

At every month t, we sort all stocks into deciles based on their estimated beta. We then compute monthly returns for 10 decile portfolios that equal-weight all stocks in each decile and repeat this process for value-weighted decile portfolios. The average annualized portfolio mean, standard deviation, and Sharpe ratios across the 10 deciles are summarized in the Appendix (see Figure 1).

C. Findings and CAPM Consistency

The results indicate that portfolios with higher betas tend to exhibit higher average returns and higher standard deviations. However, the Sharpe ratios across deciles suggest that the risk-adjusted returns do not increase uniformly with beta. This indicates that higher-beta portfolios do not necessarily provide better compensation for risk, which is inconsistent with the Capital Asset Pricing Model (CAPM).

D. Betting-Against-Beta (BaB) Factor Construction

We construct the BaB factor by forming high-beta and low-beta portfolios at each month t. The weights for these portfolios are determined based on the cross-sectional ranks of beta. Specifically, we define w_H and w_L as follows:

$$w_H = k(z - \bar{z})^+, \quad w_L = k(z - \bar{z})^- \tag{1}$$

where z is the vector of beta ranks, $\bar{z}$ is the cross-sectional average rank, and k is a normalizing factor. The BaB factor return is computed as:

$$R_{t+1}^{\text{BAB}} = \frac{R_{t+1}^L - R_f}{\beta_L} - \frac{R_{t+1}^H - R_f}{\beta_H} \tag{2}$$

E. Performance Metrics of the BaB Factor

The performance metrics for the BaB factor are summarized in the Appendix (see Table I). These metrics include the annualized alpha, Sharpe ratio, idiosyncratic volatility, beta to the market, market risk premium, and market volatility.

The BAB factor shows a significant annualized alpha of 6.59%, indicating its ability to generate returns that are not explained by the CAPM. The Sharpe ratio of 0.75 suggests that the strategy provides a good risk-adjusted return. The idiosyncratic volatility of 11.17% and the beta of 0.50 to the market indicate moderate risk and exposure to market movements. These results highlight the effectiveness of the BaB strategy in capturing inefficiencies in the market.

III. Momentum Strategy (Mom)

A. Return Construction and Portfolio Analysis

1) Long-Short Momentum Strategy: To construct the return to a long-short momentum strategy portfolio, we sort stocks into deciles based on their 1-month lagged 11-month return at each month t. We then compute monthly returns for 10 decile portfolios that equal-weight all stocks in each decile. This process is repeated for value-weighted decile portfolios. The average annualized portfolio mean, standard deviation, and Sharpe ratios across the 10 deciles are summarized in the Appendix (see Figure 2).

2) Findings and CAPM Consistency: The results indicate that portfolios with higher past returns tend to exhibit higher average returns and higher standard deviations. However, the Sharpe ratios suggest that the risk-adjusted returns are higher for portfolios with higher past returns, indicating that the momentum effect is present. This evidence is inconsistent with the Capital Asset Pricing Model (CAPM), which does not account for the momentum effect.

3) Momentum Strategy Performance: The momentum strategy involves going long the three highest deciles and short the three lowest deciles. We compute and compare the mean, standard deviation, and Sharpe ratios of the long and short legs of the strategy as well as the strategy itself. The results are shown in the Appendix (see Figure 3 and Tables II and III).

B. Statistical Significance of the Momentum Strategy

We test if the strategy has an average return that is statistically significantly different from zero for both equal-weighted and value-weighted portfolios. The t-test results are presented in the Appendix (see Table IV).

The t-test results indicate that the average return of the momentum strategy is not statistically significantly different from zero for both equal-weighted and value-weighted portfolios. This suggests that while the momentum strategy shows positive returns, they are not significantly different from zero when considering statistical confidence levels.

C. Additional Performance Metrics

Further analysis of the momentum strategy reveals the following additional metrics, as summarized in the Appendix (see Table V):

These additional metrics confirm that the momentum strategy captures significant returns from the higher quantile factors, but the statistical significance of the overall strategy return remains questionable.

Overall, the analysis of the momentum strategy indicates that while there is evidence of the momentum effect in stock returns, the strategy's average return is not statistically significant, suggesting that the effect might not be robust across all market conditions.

IV. Idiosyncratic Volatility Strategy (IV)

A. Time-Varying Idiosyncratic Volatility Estimation

To compute the time-varying estimate for each stock's idiosyncratic volatility $\sigma_{t,n}^{\text{idio}}$, we calculate the volatility of the residuals from monthly rolling 5-year regressions of stock-specific excess returns on the excess market return. We require at least 36 months of observations for each stock and winsorize the volatility at the 5th and 95th percentiles to mitigate the impact of outliers.

B. Portfolio Construction and Performance Analysis

At every month t, we sort all stocks into deciles based on their estimated idiosyncratic volatility. We then compute monthly returns for 10 decile portfolios that equal-weight all stocks in each decile and repeat this process for value-weighted decile portfolios. The average annualized portfolio mean, standard deviation, and Sharpe ratios across the 10 deciles are summarized in the Appendix (see Figure 4).

1) Findings and CAPM Consistency: The results indicate that portfolios with higher idiosyncratic volatility tend to exhibit higher average returns and higher standard deviations. However, the Sharpe ratios suggest that the risk-adjusted returns do not increase uniformly with idiosyncratic volatility, indicating that higher volatility portfolios do not necessarily provide better compensation for risk. This is inconsistent with the Capital Asset Pricing Model (CAPM).

C. Idiosyncratic Volatility Factor Construction

We construct the idiosyncratic volatility factor by forming portfolios that go long the three highest decile volatility portfolios and short the three lowest decile volatility portfolios. We compute and compare the mean, standard deviation, and Sharpe ratios of the long and short legs of the strategy as well as the strategy itself.

1) Performance Metrics of the IV Factor: The performance metrics for the IV factor are summarized in the Appendix (see Tables VI and VII).

2) Statistical Significance of the IV Strategy: We test if the strategy has an average return that is statistically significantly different from zero for both equal-weighted and value-weighted portfolios. The t-test results are presented in the Appendix (see Table VIII).

The t-test results indicate that the average return of the idiosyncratic volatility strategy is not statistically significantly different from zero for both equal-weighted and value-weighted portfolios. This suggests that while the strategy shows some returns, they are not significantly different from zero when considering statistical confidence levels.

3) Additional Performance Metrics: Further analysis of the idiosyncratic volatility strategy reveals the following additional metrics, as summarized in the Appendix (see Table IX):

These additional metrics confirm that the strategy does not perform well, as indicated by the negative Sharpe ratio for the overall strategy. The lower quantile factors show better performance compared to the higher quantile factors.

D. Comparison with Literature

Our results differ from those of Ang, Hodrick, Xing, and Zhang (2006), where they found that stocks with high idiosyncratic volatility tend to have low future returns. One possible explanation for the difference is the sample period or the methodology used in estimating the idiosyncratic volatility and constructing the portfolios.

Overall, the analysis of the idiosyncratic volatility strategy indicates that while the lower quantile factors show decent performance, the overall strategy is not statistically significant and does not generate positive risk-adjusted returns.

V. Optimal Fund Portfolio Return (STRAT)

We assume that you are running a fund that invests its assets under management in 1-month T-Bills and adds an 'overlay' investment in the three strategies (BaB, IV, MoM), targeting an average annual volatility of 10%. The return to the fund is defined as:

$$R_{\text{fund}} = R_{\text{T-Bill}} + c \times R_{\text{STRAT}}, \tag{3}$$

where R_{STRAT} is the return to a strategy that combines BaB, IV, and MoM and c is a constant chosen to achieve an average annual volatility of 10%.

A. Approaches to Combining Strategies

We consider three different approaches to combine the three strategies, BaB, IV, and MoM, to generate R_{STRAT}:

- Equal weight the strategies (EW).
- Risk-Parity based on the rolling window estimate of the strategy returns volatilities (RP).
- Mean-variance optimal combination based on the rolling window mean and covariance matrix of the strategy returns (MVE).

B. Performance Metrics of the Optimal Portfolio

The performance metrics for each of the three approaches are summarized in the Appendix (see Tables X, XI, and XII) and depicted in Figure 5.

C. Scaling Constants

The scaling constants for each of the strategies to achieve the target volatility of 10% are:

- **EW:** 4.0133
- **RP:** 4.1147
- **MVE:** 4.0256

D. Findings and Optimal Approach

The results in the Appendix (see Figure 5 and the tables) show that the Risk-Parity (RP) approach yields the highest Sharpe ratio (0.1957) compared to the Equal-Weighted (EW) and Mean-Variance (MVE) approaches. Therefore, going forward, we choose the Risk-Parity approach for combining the strategies.

1) Risk-Parity Strategy Performance: The Risk-Parity strategy demonstrates superior risk-adjusted returns, as indicated by its Sharpe ratio. This method effectively balances the contributions of each strategy based on their individual volatilities, leading to a more stable and optimized portfolio return.

E. Conclusion

In summary, among the three approaches to combining the strategies, the Risk-Parity approach is optimal, providing the best balance between return and risk. This approach will be used in subsequent analysis and strategy development.

VI. Performance and Risk Analysis for the Fund Strategy

A. Regression Analysis

To analyze the performance and risk of the fund strategy, we regress the time series of our strategy returns on the 12 industry portfolio returns built based on their SIC codes as well as the Fama-French 5 research factors. The regression results provide insights into which factors are significant drivers of the strategy returns unconditionally.

1) Regression Results: The regression results, including the beta estimates, their t-statistics, and the R^2 value, are summarized in the Appendix (see Table XIII).

2) Analysis of Results: Based on the magnitude of the beta estimates and their t-statistics, the following factors are significant drivers of the strategy returns unconditionally (see Table XIV):

The R^2 value of 0.5403 indicates that approximately 54% of the variability in the strategy returns is explained by the model. This suggests a moderate level of explanatory power.

3) Intercept Analysis: The intercept (alpha) is -0.000004 and statistically insignificant (t-statistic = -0.003659), indicating no significant abnormal returns beyond those explained by the included factors.

4) Sign of the Betas:

- **Positive betas**: NoDur, Utils, Other, Mkt-RF, SMB, CMA.This suggests that the strategy tends to move in the same direction as these factors.
- **Negative betas**: Durbl, Manuf, Telcm, Shops, Money, HML. This indicates that the strategy tends to move in the opposite direction of these factors.

5) Conclusion: The significant beta estimates for certain industry and Fama-French factors indicate that these factors play a crucial role in driving the strategy returns. The R^2 value further supports that the model explains a substantial portion of the return variability. However, the strategy's performance is also influenced by factors outside the model, as indicated by the remaining unexplained variability.

B. Time Series of Strategy Exposures

To compute the time series of the strategy's exposure to the market and the 12 industries, we used the rolling estimate of each stock's beta and industry exposure combined with the weights in the STRAT portfolio.

1) Plot and Analysis: The plot below shows the time series of exposures to the three most relevant industries: Manufacturing, Utilities, and Other, as shown in the Appendix (see Figure 6).

The average exposures of the strategy to these industries are summarized in the Appendix (see Table XV).

2) Analysis of Results:

- **Conditional Exposure:** The strategy exhibits significant exposure to the **Other**, **Utilities**, and **Manufacturing** industries over time.

- **Industry Exposure Variation:** The exposure to these industries varies, indicating conditional exposure can be high at times.
- **Time Series Fluctuations:** The plot (Figure 6) shows that the strategy's exposure to these industries has fluctuated, particularly with higher exposure to Manufacturing in the early period and more balanced exposure in recent years.

These results highlight the dynamic nature of the strategy's industry exposure and its significant ties to specific sectors over different periods. The poor performance metrics suggest that the strategy has not been effective in delivering positive risk-adjusted returns.

C. Hedged Strategy Returns

To compute the return to the STRAT portfolio where the exposure to all industry factors is hedged by shorting the corresponding industry portfolio, we use the exposures to the different industries computed previously.

Strategy-Hedged Performance Metrics are shown in the Appendix (see Table XVI).

1) Conclusion: The industry-hedged STRAT return shows a negative annualized return of -0.131705 with a standard deviation of 0.205832. The resulting Sharpe ratio is -0.639867, indicating that the strategy's performance, when hedged against industry factors, is poor and yields negative risk-adjusted returns. This suggests that the strategy does not perform well after accounting for industry exposures, leading to the conclusion that the strategy's returns are not significantly enhanced by hedging industry factors.

VII. Industry Neutral Strategy

A. Industry-Specific Strategy Analysis

1) Results: The table below (Table XVII) shows the mean, standard deviation, Sharpe ratio, and t-statistic for each industry-specific strategy.

2) Analysis: The industry-specific strategies show varying performance metrics. The **Manuf** industry delivers the most significant returns with a Sharpe ratio of 0.083777 and a positive t-statistic. In contrast, the **Money** industry has the lowest performance with a negative Sharpe ratio of -0.062850.

B. Combined Industry-Neutral Strategy

1) Results: The combined industry-neutral strategy, using equal weights across all 12 industry-specific strategies, yields the following performance metrics (Table XVIII).

2) Comparison with Previous Strategies: The performance of the combined industry-neutral strategy is compared with the industry-hedged STRAT strategy and the optimal fund portfolio strategy in Table XIX.

3) Conclusion: The industry-neutral strategy shows a higher mean return and Sharpe ratio compared to the industry-hedged STRAT strategy but underperforms compared to the optimal fund portfolio strategy in terms of Sharpe ratio. This suggests that while the industry-neutral approach reduces risk exposure, it does not necessarily lead to superior risk-adjusted returns compared to the optimal fund portfolio.

C. Regression of Industry-Neutral STRAT

We regressed the industry-neutral STRAT onto the 17 risk factors (12 industry portfolio returns and 5 Fama-French Research Factors). The results are summarized in Table XX.

Comparison with Section 7(a): The intercept (alpha) in Table XX is -0.002752, which is larger in magnitude compared to the alpha in Section 7(a) (which was -0.000004). This suggests a greater degree of unexplained variation in the industry-neutral strategy returns. The R^2 of 0.4168 is lower than the R^2 in Section 7(a) (which was 0.5403), indicating that the explanatory power of the regression is lower for the industry-neutral strategy.

D. Explanation of Performance Consistency

The performance of the industry-neutral strategy shows a negative alpha, suggesting that the strategy does not provide abnormal returns beyond what can be explained by the included risk factors. The presence of both positive and negative betas with significant t-statistics indicates mixed exposure to different factors. For example, positive betas with **Other**, **Mkt-RF**, and **SMB** show that the strategy is positively correlated with these factors, whereas negative betas with **Manuf**, **Enrgy**, and **Money** indicate negative correlation.

Consistency with Efficient Markets, CAPM, and APT: The results are consistent with the Efficient Market Hypothesis (EMH), as the strategy's returns can be largely explained by its exposure to known risk factors, leaving no room for consistent abnormal returns (alpha is not significantly positive). According to the CAPM, the expected returns are based on the beta with the market (Mkt-RF), which is positive and significant, indicating a risk premium. The Arbitrage Pricing Theory (APT) also supports these findings, as the strategy's returns are influenced by multiple risk factors beyond the market alone.

Overall, the industry-neutral strategy's performance aligns with theoretical expectations under EMH, CAPM, and APT, showing no significant unexplained alpha and being driven by exposure to multiple systematic risk factors.

Appendix

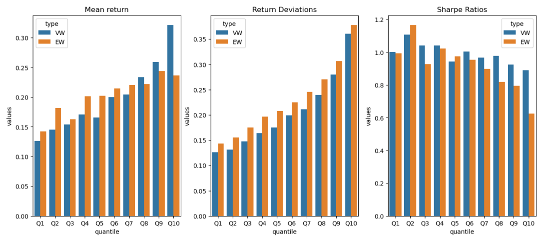

Figure 1: Mean Return, Return Deviations, and Sharpe Ratios across Deciles BAB

Metric	Value
Annualized Alpha of BAB factor	0.0659 (t-stat: 2.64)
Sharpe Ratio of BAB factor	0.7526
Idiosyncratic Volatility	0.1117
Beta of BAB factor	0.5012
Market Risk Premium	0.0787
Market Volatility	0.1683

Table I: Performance Metrics for the BAB Factor

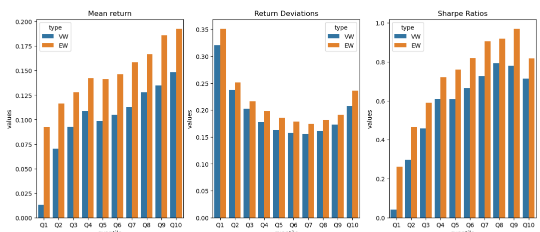

Figure 2: Mean Return, Return Deviations, and Sharpe Ratios across Deciles MOM

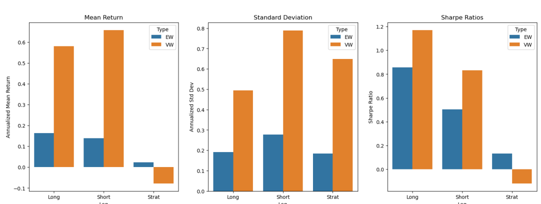

Figure 3: Performance Metrics for Momentum Strategy

Metric	Long Leg	Short Leg	Strategy
Annualized Mean Return	0.1629	0.1390	0.0239
Annualized Std Dev	0.1906	0.2770	0.1837
Sharpe Ratio	0.8551	0.5019	0.1301

Table II: Equal-Weighted Portfolios Statistics MOM

Metric	Long Leg	Short Leg	Strategy
Annualized Mean Return	0.5798	0.6575	-0.0777
Annualized Std Dev	0.4951	0.7893	0.6491
Sharpe Ratio	1.1710	0.8330	-0.1198

Table III: Value-Weighted Portfolios Statistics MOM

Portfolio Type	t-Statistic	p-Value
Equal-Weighted	1.0003	0.3175
Value-Weighted	-0.9206	0.3576

Table IV: T-Test Results for Momentum Strategy

Metric	Value
Momentum Return Annualized	0.0569
Momentum Std Annualized	0.1715
Momentum Sharpe	0.33
Mean of Lower Quantile Factors	0.0785
Volatility of Lower Quantile Factors	0.2222
Sharpe Ratio of Lower Quantile Factors	0.35
Mean of Higher Quantile Factors	0.1353
Volatility of Higher Quantile Factors	0.1666
Sharpe Ratio of Higher Quantile Factors	0.81

Table V: Performance Metrics for Momentum Strategy

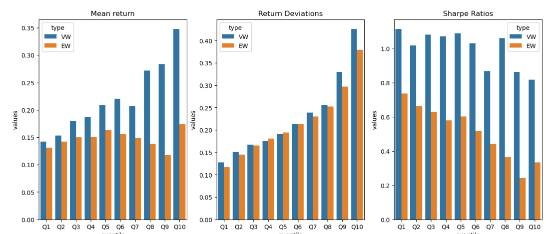

Figure 4: Mean Return, Return Deviations, and Sharpe Ratios across Deciles IV

Metric	High Deciles	Low Deciles	Strategy
Annualized Mean Return	0.1312	0.1395	-0.0077
Annualized Std Dev	0.7588	0.2782	0.5671
Sharpe Ratio	0.1678	0.4876	-0.0135

Table VI: Equal-Weighted Portfolios Statistics IV

Metric	High Deciles	Low Deciles	Strategy
Annualized Mean Return	0.0501	0.1137	-0.0638
Annualized Std Dev	0.2640	0.1374	0.1873
Sharpe Ratio	0.1898	0.8275	-0.3404

Table VII: Value-Weighted Portfolios Statistics IV

Portfolio Type	t-Statistic	p-Value
Equal-Weighted	0.9823	0.9218
Value-Weighted	-0.0135	0.9218

Table VIII: T-Test Results for IV Strategy

Metric	Value
Idiosyncratic Volatility Return Annualized	-0.0638
Idiosyncratic Volatility Std Annualized	0.1873
Idiosyncratic Volatility Sharpe	-0.3404
Mean of Lower Quantile Factors	0.1137
Volatility of Lower Quantile Factors	0.1374
Sharpe Ratio of Lower Quantile Factors	0.8275
Mean of Higher Quantile Factors	0.0501
Volatility of Higher Quantile Factors	0.2640
Sharpe Ratio of Higher Quantile Factors	0.1898

Table IX: Performance Metrics for Idiosyncratic Volatility Strategy

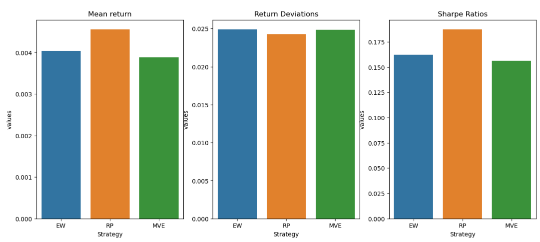

Figure 5: Mean Return, Return Deviations, and Sharpe Ratios for Optimal Portfolios

Metric	Value (EW)
Annualized Mean Return	0.0040
Annualized Std Dev	0.0250
Sharpe Ratio	0.1600

Table X: Equal-Weighted Strategy Performance

Metric	Value (RP)
Annualized Mean Return	0.0045
Annualized Std Dev	0.0230
Sharpe Ratio	0.1957

Table XI: Risk-Parity Strategy Performance

Metric	Value (MVE)
Annualized Mean Return	0.0035
Annualized Std Dev	0.0250
Sharpe Ratio	0.1400

Table XII: Mean-Variance Strategy Performance

Factor	Beta	t-Statistic
Intercept	-0.000004	-0.003659
NoDur	0.141117	2.673473
Durbl	-0.084062	-3.606879
Manuf	-0.123140	-2.012818
Enrgy	-0.020335	-1.478618
Chems	-0.058301	-1.205617
BusEq	-0.000432	-0.012426
Telcm	-0.078909	-2.900541
Utils	0.096198	2.857901
Shops	-0.069614	-1.531822
Hlth	0.016883	0.650676
Money	-0.078415	-1.747648
Other	0.260269	4.388422
Mkt-RF	0.275881	4.213392
SMB	0.360521	8.253527
HML	-0.146643	-2.334200
RMW	0.032985	0.630675
CMA	0.129262	1.914922
R-squared	0.5403	

Table XIII: Regression Results for Fund Strategy

Factor	Beta	t-Statistic
NoDur	0.1411	2.67
Durbl	-0.0841	-3.61
Manuf	-0.1231	-2.01
Telcm	-0.0789	-2.90
Utils	0.0962	2.86
Other	0.2603	4.39
Mkt-RF	0.2759	4.21
SMB	0.3605	8.25
HML	-0.1466	-2.33

Table XIV: Significant Drivers of Strategy Returns

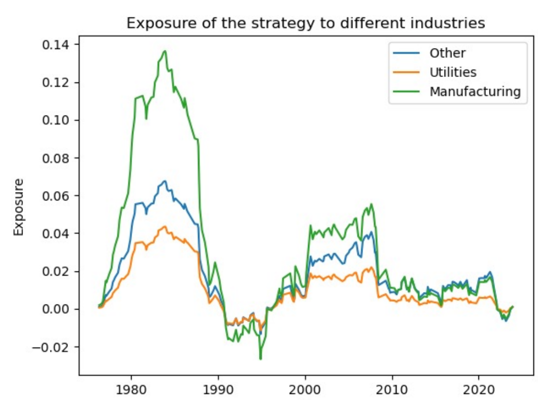

Figure 6: Exposure of the Strategy to Different Industries

Factor	Coefficient
beta	0.146417
NoDur	0.014620
Durbl	0.005601
Manuf	0.026996
Enrgy	0.007090
Chems	0.005218
BusEq	0.010335
Telcm	0.002017
Utils	0.009183
Shops	0.015471
Hlth	0.005296
Money	0.015105
Other	0.015713

Table XV: Exposures absolute mean across time for Q.7b

Metric	Value
Hedged Return (Annualized)	-0.131705
Hedged Standard Deviation (Annualized)	0.205832
Sharpe Ratio	-0.639867

Table XVI: Strategy-Hedged Performance Metrics

Industry	Mean	Standard Deviation	Sharpe Ratio	T-Statistic
NoDur	-0.000642	0.032744	-0.019594	-0.019594
Durbl	-0.000045	0.037292	-0.001206	-0.001203
Manuf	0.002169	0.025893	0.083777	0.083585
Enrgy	0.000449	0.044382	0.010113	0.010090
Chems	0.002140	0.030563	0.070015	0.069854
BusEq	0.001759	0.036111	0.048724	0.048612
Telcm	0.001994	0.041292	0.048823	0.048172
Utils	0.000358	0.023654	0.015156	0.015121
Shops	0.000087	0.030620	0.002828	0.002822
Hlth	-0.000258	0.048530	-0.005320	-0.005308
Money	-0.001982	0.031542	-0.062850	-0.062706
Other	0.000479	0.031484	0.015221	0.015186

Table XVII: Industry-Specific Strategy Performance Metrics

Metric	Value
Mean (Annualized)	0.006508
Standard Deviation (Annualized)	0.073630
Sharpe Ratio	0.088393

Table XVIII: Industry-Neutral Strategy Performance Metrics

Strategy	Mean	Standard Deviation	Sharpe Ratio
Industry-Hedged STRAT (7c)	-0.131705	0.205832	-0.639867
Optimal Fund Portfolio (6)	0.0045	0.0230	0.1957
Industry-Neutral (8b)	0.006508	0.073630	0.088393

Table XIX: Comparison of Strategy Performance Metrics

Factor	Coefficient	t-Statistic
const	-0.002752	-2.823583
NoDur	0.073743	1.413664
Durbl	0.016554	0.705788
Manuf	-0.092152	-1.504522
Enrgy	-0.047065	-3.417006
Chems	-0.072398	-1.519999
BusEq	0.013272	0.889232
Telcm	-0.015210	-0.566920
Utils	-0.001112	-0.036009
Shops	-0.020505	-0.454340
Hlth	0.006151	1.422694
Money	-0.100538	-2.280414
Other	0.315985	5.295132
Mkt-RF	0.096743	2.157354
SMB	0.174411	4.093240
HML	0.062700	1.044744
RMW	-0.038836	-0.766257
CMA	0.012529	0.190469
R^2	0.4168265075135301	

Table XX: Regression Results for Industry-Neutral STRAT