Quantitative Analysis of Anomaly-Based Trading Strategies

Garrett Mills, Deepak Punjabi, Deepak Tiwari, Marshall Titch

MBA524 Final Paper

Table of Contents

Part I: Introduction

Market efficiency refers to the idea that arbitrage opportunities are few and far between and self-correcting, because market prices reflect all available and relevant information available at any given time; resulting in no undervalued or overvalued securities. Anomalies are market inefficiencies that contradict the efficient market hypothesis because they should not occur at all and should not persist but are observed to occur nonetheless; randomly resulting from various and often unpredictable market conditions. Examples of anomalies include value, momentum, and gross profit anomalies (Kenton, 2018).

Value anomalies occur when investors overly estimate future earning and returns of growth stocks and underestimate the future earnings and returns of value stocks. Momentum anomalies are when recent past performance/trends continue in the short-term future since winners typically continue to win and losers typically continue to lose (Canaday, 2009). Lastly, gross profit anomalies are where firms with higher gross profits have higher expected returns. Taking advantage of these anomalies to seek higher profits is a possibility, however, trading costs and taxes may be significant enough to eliminate any additional profits resulting from the strategies. Additionally, some trading strategies that target these anomalies may produce higher returns, but due to the additional risk associated with various local and global factors related to them strategies, returns must be risk-adjusted to truly identify whether investors beat the market (Asness, Moskowitz, & Pederson, 2013).

The main finding was that value and momentum effects exist across global asset classes beyond just equities; including bonds, commodities, currencies, etc. Additionally, an abnormal finding was that when momentum is good, it's good across all asset classes i.e. momentum stocks and momentum bonds move together as opposed to opposite directions, and value stocks and value

bonds also move together. This was majorly attributed to behavioral errors like people overreacting, sentiment being high, and/or people being excited about growth stocks or other assets that have been doing well recently (Asness, Moskowitz, & Pederson, 2013).

Since value and momentum are negatively correlated, combining them into one portfolio will improve average excess returns while reducing standard deviation to provide a better Sharpe ratio through diversification. This is especially fruitful since both strategies individually are positive expected return strategies, that when combined significantly improve expected excess returns (alphas) while reducing standard deviation (Asness, Moskowitz, & Pederson, 2013).

Typically, firms with high profitability have higher expected returns, but an investor must still account for whether the firms' share prices are overpriced, which would not make them a "buy." To find some way to balance these considerations, this strategy focuses on using gross profits over assets rather than earnings over assets, because profitability is about future for profits; not about what you earn today. Using today's earnings, which are diluted by one-time expenses and revenue generating events will skew expectations for future profitability whereas gross profits doesn't have that issue. By taking a ratio of gross profits by assets for many firms and sorting them according to their ratios, the investor could buy firms with high gross profits to assets (positive alphas) and short firms with low gross profits to assets (negative alphas) (Novy-Marx, 2013).

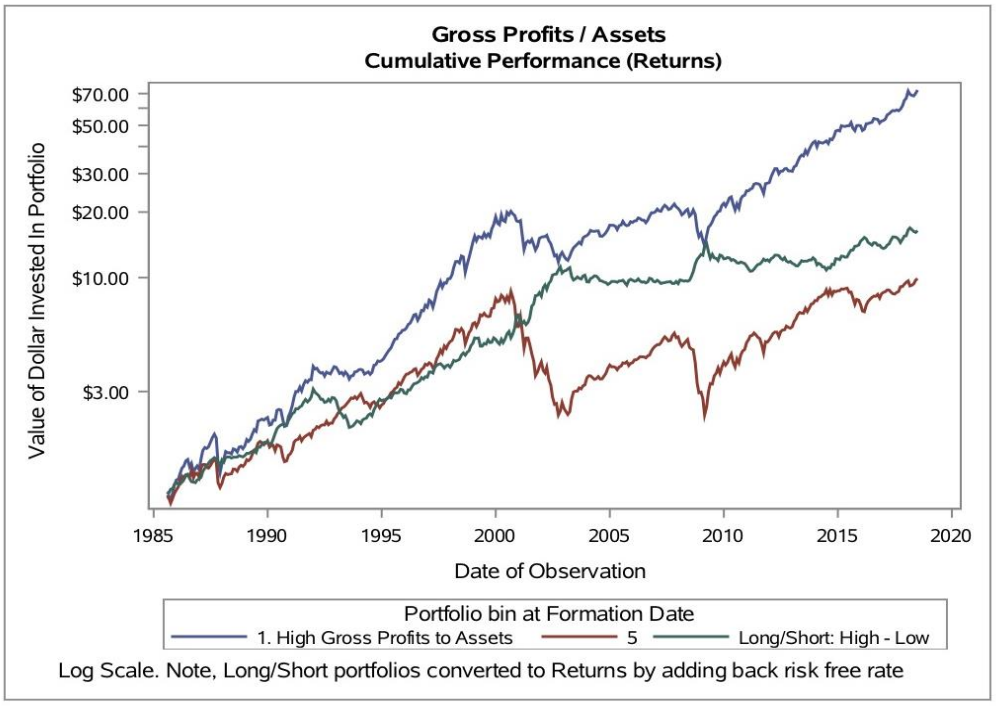
This strategy is simple and predictable but can be enhanced by combining it with another negatively correlated strategy like the value strategy discussed above. Similar to value and momentum, combining the two negatively correlated positive expected return strategies will improve Sharpe ratios by increasing returns while minimizing standard deviation through portfolio diversification (Novy-Marx, 2013).

Part II: Testing the Gross Profit Anomaly

We test the presence of the Gross Profit anomaly by analyzing a historic database composed of a merged stock returns data (CRSP) and accounting data (Compustat). Specifically, we sort the stocks into quintiles based on their Gross Profit / Total Assets ratio and test the historical performance of several portfolios based on these quintiles.

Our hypothetical portfolios consist of value-weighted stocks from one of the five quintiles described above. In addition to these five portfolios, we consider a portfolio that is long stocks from the highest Gross Profit / Total Asset quintile and short stocks from the lowest Gross Profit / Total Asset quintile on a value-weighted basis. In this long-short portfolio, the long positions are entirely funded by the short positions. All portfolios are tested from period beginning July 1st, 1985 and ending December 31st, 2016. All portfolios are rebalanced every July so that they retain the appropriate characteristics over time.

The plot below shows the growth of one dollar invested into the highest quintile portfolio, lowest quintile portfolio, and long-short portfolio. The plot shows the stocks with the highest profit ratios vastly outperforming those with the lowest ratios. Then ending portfolio value for high ratio stocks is nearly 7 times higher than for the low ratio stocks. Note that the long short portfolio achieves positive returns despite requiring no initial capital.



While the graph shows cumulative returns are higher for the high Gross Profit / Asset firms, it does not consider whether they achieved those returns by incurring higher risk. Below, we present Sharpe ratios for each strategy. Sharpe ratio is the ratio of excess returns to volatility of returns. Maximizing Sharpe ratio is a common investment objective, as it attempts to account for both risk and return.

Gross Profits / Assets
Sharpe Ratio by bin

Portfolio bin at Formation Date	Mean Excess Return	Standard Deviation of Excess Returns	Sharpe Ratio
1. High Gross Profits to Assets	0.93%	4.58%	0.20
2	0.74%	4.93%	0.15
3	0.74%	4.78%	0.16
4	0.57%	4.89%	0.12
5	0.44%	4.95%	0.09
Long/Short: High - Low	0.49%	3.10%	0.16

The analysis shows the highest Sharpe ratio for the high Gross Profit / Assets stocks. This is strong evidence that the stock returns are anomalous.

A more rigorous approach to determining whether the excess returns are due to risk or anomaly is to investigate the presence of alpha in Fama-French regressions. Fama-French is a model that attempts to explain excess returns as a linear relationship with factors related to size, book-to-market ratio, and “beta.” Between these factors, the model hopes to explain all variation in return. However, the presence of alpha suggests there is additional return that is not explained by risk factors. The Fama-French regressions will tell us whether these returns are actually are anomalous. The table below gives the coefficients and t-statistics for the CAPM and Fama-French models for each trading strategy’s returns.

Gross Profits / Assets
Factor Regression Results

Thursday, May 2, 2019 01:26:15 PM

Obs	bin	_TYPE_	alpha_capm	mktrf_capm	alpha_ff3	mktrf_ff3	smb	hml
1	1. High Gross Profits to Assets	PARMS	0.26	0.97	0.33	0.95	-0.12	-0.26
2	1. High Gross Profits to Assets	T	2.83	46.68	3.93	48.26	-4.25	-8.61
3	2	PARMS	0.02	1.04	0.11	1.01	-0.07	-0.31
4	2	T	0.22	47.82	1.23	49.74	-2.54	-9.82
5	3	PARMS	0.03	1.04	0.05	1.02	0.03	-0.09
6	3	T	0.35	57.56	0.68	55.41	1.06	-3.13
7	4	PARMS	-0.14	1.03	-0.21	1.07	-0.03	0.23
8	4	T	-1.44	47.31	-2.27	50.59	-0.98	7.17
9	5	PARMS	-0.28	1.04	-0.29	1.04	0.05	0.05
10	5	T	-2.68	44.27	-2.80	42.77	1.43	1.34
11	Long/Short: High - Low	PARMS	0.54	-0.07	0.62	-0.09	-0.17	-0.31
12	Long/Short: High - Low	T	3.41	-1.92	4.09	-2.49	-3.33	-5.69

A few metrics of this table are noteworthy. First, the highest Gross Profits / Assets bin has positive alpha with high significance in both the CAPM and Fama-French models, whereas the lowest Gross Profit / Assets bin has negative alpha in both CAPM and Fama-French models with high significance. The long-short strategy also has significant, positive alpha. This is further strong evidence that the Gross Profit / Assets anomaly indeed exists. The Fama-French models estimated are very close to the results from Novy-Marx, who found alphas of 0.34 and -0.18 for high and low bins, compared to our 0.33 and -0.28.

Part III: Comparison of Investment Strategies

Part II analyzed the phenomenon of high Gross Profit / Asset companies earning higher returns with only slightly higher risk. This is evidence that the ratio is an anomaly. However, the trading strategies under consideration in this paper are designed to combine this anomaly with the value anomaly. Because various anomalies can exhibit correlations in either direction, it is unclear that combining two anomalies will produce a better risk-return profile than a passive market portfolio. In this section, we examine the combined portfolio strategies under consideration by AQR and compare them to the market portfolio.

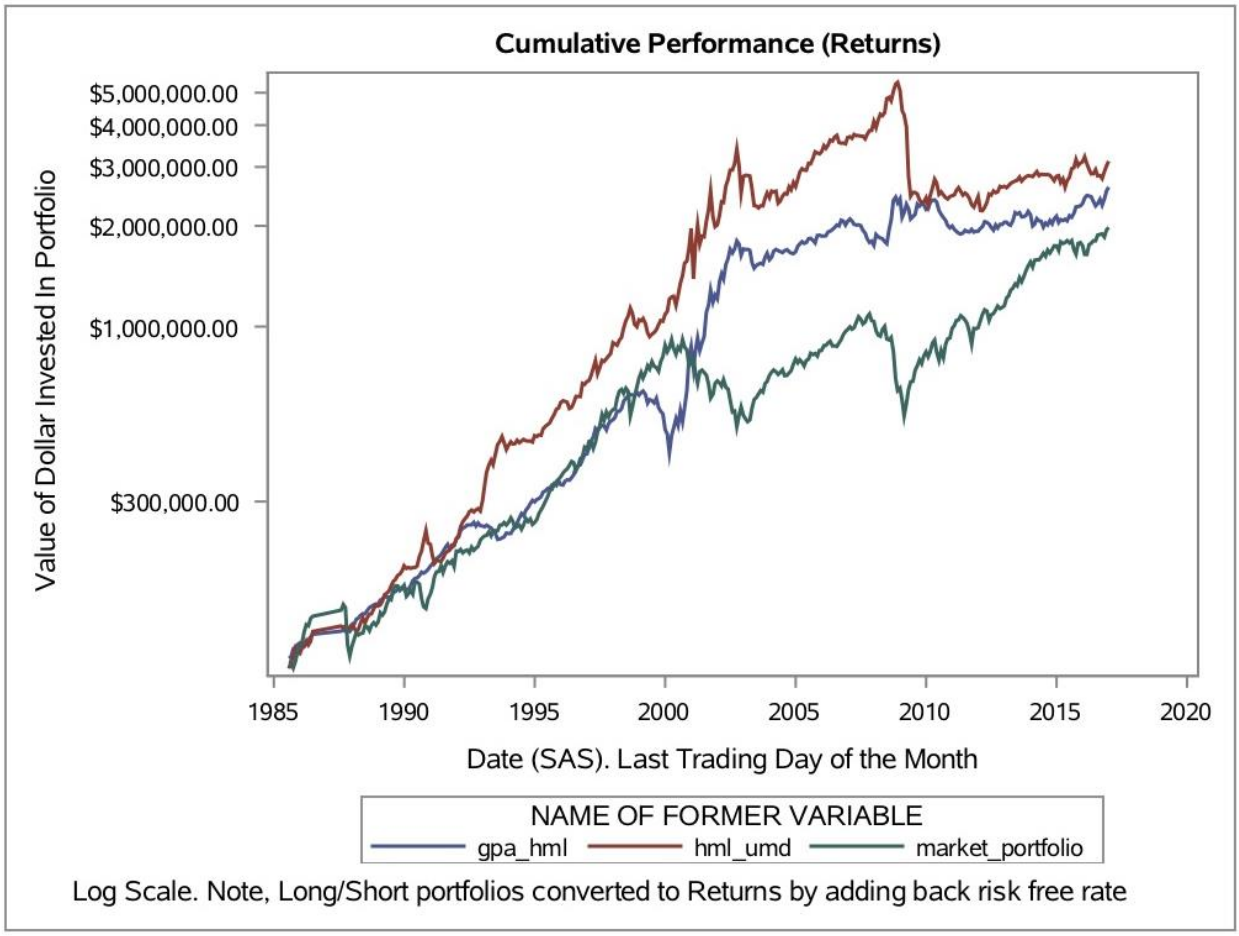
Let us study some basic summary statistics of the monthly returns of the strategies.

The MEANS Procedure

Variable	N	Mean	Median	Std Dev	Minimum	Maximum	1st Pctl	Skewness
gpa_hml	366	0.0096759	0.0092025	0.0385658	-0.1392466	0.2619341	-0.1022174	1.0192332
hml_umd	366	0.0107538	0.0125500	0.0501592	-0.2942000	0.2579000	-0.1629000	-1.1243413
market_portfolio	366	0.0091784	0.0143500	0.0439765	-0.2264000	0.1135000	-0.1021000	-0.9562014

The highest average monthly returns come from the Value plus Momentum strategy, followed by Gross Profit plus Value and then the market portfolio. However, Value plus Momentum also has highest standard deviation of returns, suggesting a risk-return tradeoff. The Profit plus Value strategy has both lower returns and higher standard deviations than the market portfolio. The skewness measure provide interesting insight into the nature of return volatility. Gross Profit plus Value has high positive skew, meaning much of its volatility comes from extremely high returns, whereas the market and Value plus Momentum strategies have high negative skewness, meaning they exhibit frequent extremely low returns.

The arithmetic mean returns can sometimes give a misleading impression of how the returns compound over time. To alleviate this, we present a plot showing how a $10,000 portfolio of each strategy would have grown the strategy were conducted from 1985-2016. Note that in reality, both anomaly strategies performed better than the market portfolio on a geometric average basis.



We have seen the returns represented in the tables and charts above. Now, we will analyze the risk trade-off for these returns. The table below shows the standard deviation and Sharpe ratio for the strategies.

Sharpe Ratio by bin

NAME OF FORMER VARIABLE	Mean Excess Return	Standard Deviation of Excess Returns	Sharpe Ratio
gpa_hml	0.70%	3.84%	0.18
hml_umd	0.80%	4.99%	0.16
market_portfolio	0.65%	4.40%	0.15

According to the Sharpe ratio, the Gross Profit plus Value has the superior risk-return tradeoff, followed by Value plus Momentum and market.

To more rigorously assess the returns of the strategies', we will again conduct regression analysis and test for alpha in the CAPM and Fama-French models.

Factor Regression Results Sunday, May 5, 2019

Obs	bin	_TYPE_	alpha_capm	mktrf_capm	alpha_ff3	mktrf_ff3	smb	hml
1	gpa_hml	PARMS	0.84	-0.22	0.60	-0.10	-0.16	0.71
2	gpa_hml	T	4.27	-5.00	3.77	-2.69	-2.96	12.57
3	hml_umd	PARMS	1.02	-0.34	0.82	-0.26	0.07	0.62
4	hml_umd	T	4.05	-5.93	3.44	-4.79	0.85	7.37
5	market_portfolio	PARMS	0.00	1.00	0.00	1.00	0.00	0.00
6	market_portfolio	T	.	.	.	.	.	.

Interestingly, the regression shows Value plus Momentum having the highest alpha. This means that relatively more of the observed returns from the Gross Profit plus Value strategy are explained by smb and hml factors. Both strategies have positive, statistically significant alpha. Of course, the market portfolio's regression output is trivial, as 100% of the market portfolio excess returns are explained by the mktrf factor.

Annual Returns

Year	gpa_hml_ret	hml_umd_ret	market_portfolio_ret
1985	13.38%	5.36%	11.89%
1986	12.18%	24.46%	16.28%
1987	18.46%	1.30%	1.60%
1988	18.14%	13.48%	17.90%
1989	10.71%	32.05%	28.88%
1990	17.22%	15.94%	-6.13%
1991	20.80%	3.83%	34.79%
1992	9.32%	29.87%	9.72%
1993	-5.06%	46.61%	11.11%
1994	24.23%	6.77%	-0.20%
1995	12.68%	25.54%	36.82%
1996	23.49%	15.60%	21.16%
1997	26.55%	30.69%	31.21%
1998	18.49%	17.02%	24.33%
1999	-21.06%	3.93%	25.25%
2000	77.02%	80.63%	-11.71%
2001	38.75%	2.38%	-11.37%
2002	40.94%	39.62%	-21.12%
2003	-7.15%	-13.64%	31.78%
2004	5.71%	7.98%	11.93%
2005	11.40%	27.15%	6.06%
2006	10.65%	10.22%	15.42%
2007	-15.16%	11.57%	5.68%
2008	37.64%	24.00%	-36.75%
2009	-7.11%	-52.29%	28.36%
2010	-10.73%	1.51%	17.48%
2011	-3.52%	-0.61%	0.46%
2012	6.43%	7.30%	16.32%
2013	5.36%	7.33%	35.17%
2014	-1.13%	-0.15%	11.71%
2015	9.19%	10.49%	0.07%
2016	11.97%	0.41%	13.52%

We can see the annual returns of each of the three strategies from 1985 to 2016. We can see that the annual returns of Gross Profit plus Value strategy were 37.64% and for Value Plus momentum was 24% in 2008 during recession where as returns of market factor portfolio was -36.75%. Hence, these strategies work well when market factor strategy tanks.

5 Best Returns

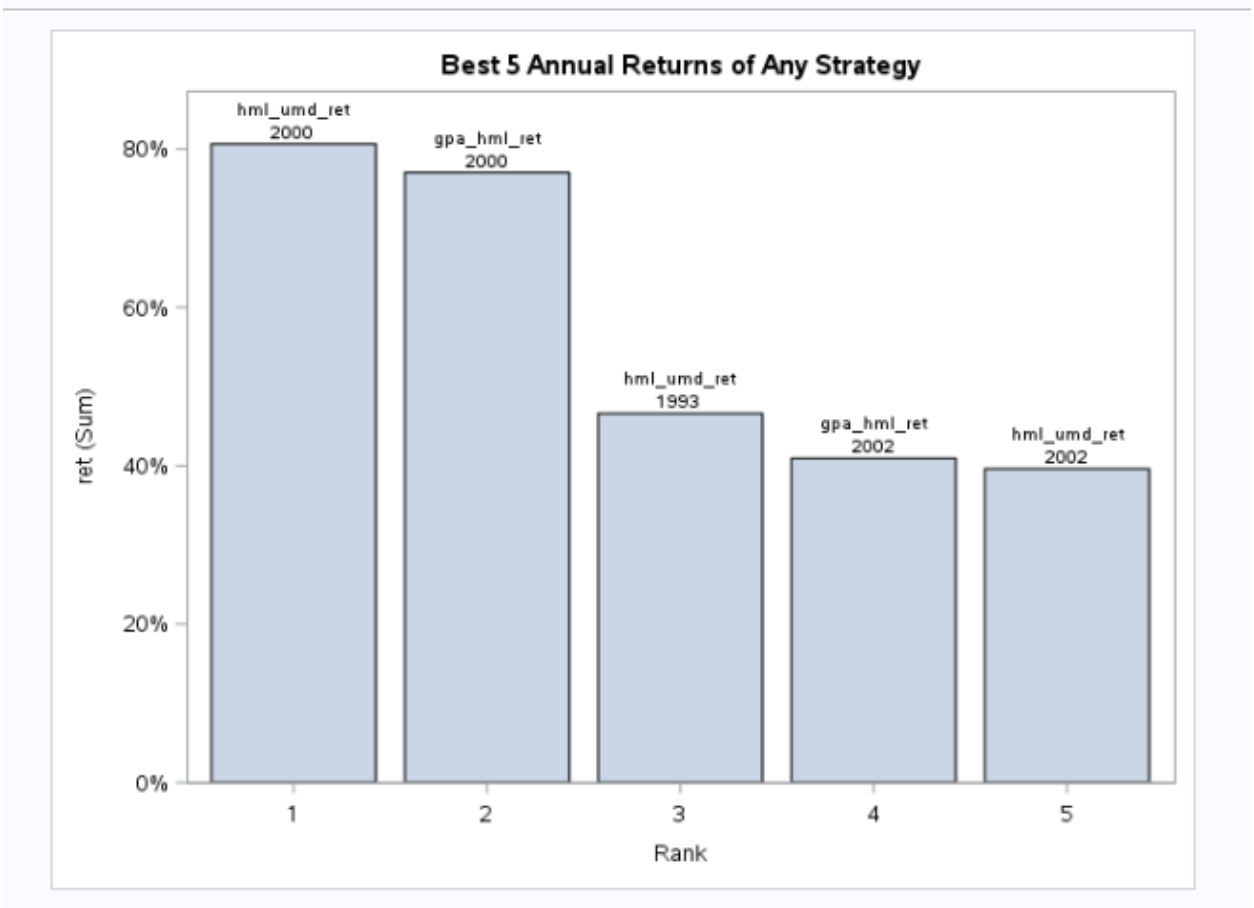
Obs	market_portfolio_ret	gpa_hml_ret	hml_umd_ret
1	36.82%	77.02%	80.63%
2	35.17%	40.94%	46.61%
3	34.79%	38.75%	39.62%
4	31.78%	37.64%	32.05%
5	31.21%	26.55%	30.69%

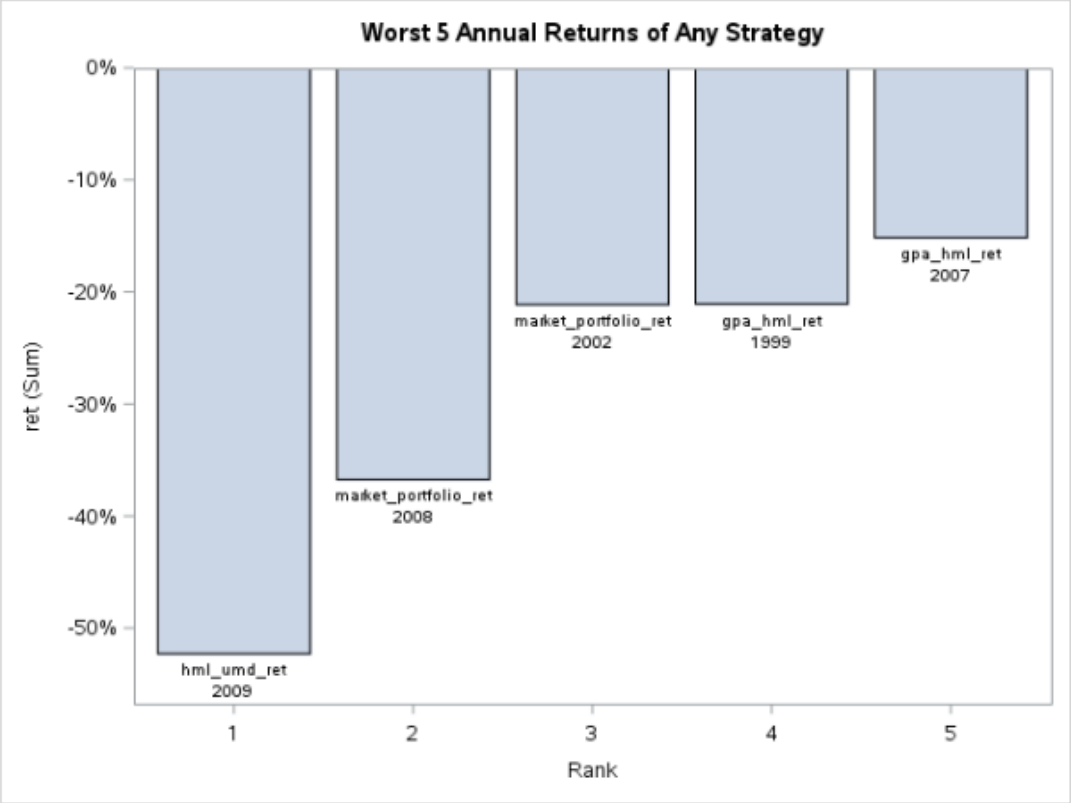
We can see the 5 best annual returns in the table above for each of the strategy The highest return for Value Plus momentum was as high as 80%.

5 Worst Returns

Obs	market_portfolio_ret	gpa_hml_ret	hml_umd_ret
1	-36.75%	-21.06%	-52.29%
2	-21.12%	-15.16%	-13.64%
3	-11.71%	-10.73%	-0.61%
4	-11.37%	-7.15%	-0.15%
5	-6.13%	-7.11%	0.41%

We can see the 5 worst annual returns in the table above for each of the strategy the worst return for Value Plus momentum was as high as -52.29%. Hence it can be noted that Value Plus momentum has the highest and lowest annual return which means this strategy is volatile as compared to Gross Profit plus Value strategy which is more stable.


Best 5 Annual Returns of Any Strategy
hml_umd_ret
2000
gpa_hml_ret
2000
hml_umd_ret
1993
gpa_hml_ret
2002
hml_umd_ret
2002
80%
60%
40%
20%
0%
ret (Sum)
1
2
3
4
5
Rank



We can see the 5 worst and best return of any of 3 strategy. We can note that market portfolio isn't included in top 5 annual returns which suggest investing in other strategies as opposed to only investing in market portfolios.

Strategy	% of Positive Years	% of Positive Months
Value_plus_Gross_Profit	75.00%	63.23%
Value_plus_Momentum	87.50%	62.96%
Market_Portfolio	81.25%	63.76%

We can see that percentage of positive returns months for each strategy is almost the same. Percentage of positive years for Value Plus momentum is highest at 87.5%.

We can use this table to see percentage of positive and negative years for each strategy and then decide which strategy to select.

Finally, we can see from above tables and graphs that Value Plus momentum has the best and worst performance.

The analysis gives compelling evidence that the two anomaly-based trading strategies have been effective over the 1985-2016 period. If the future markets conditions resemble this period, then either strategy is well positioned to deliver superior returns with only slightly higher risk. Two critical parts of our analysis favor the Value plus Momentum strategy: one, the cumulative returns outperformed any other strategy and two, the Fama-French alpha was observed to be higher and more significant than any other strategy. However, due to our skepticism about the economic fundamentals of the momentum strategy, we still recommend the Gross Profit plus Value strategy. The Value plus Momentum strategy's momentum component could make the firm highly exposed to asset price bubbles. This will lead to occasional devastating losses that could endanger the fund. This risk is demonstrated by the negative skew of Value plus Momentum. On the other hand, Gross profit plus Value is more closely linked to business fundamentals (and with positive skew), increasing the likelihood that the anomaly is built from stocks who are genuinely undervalued, and not just stocks who are currently in the news. ***We conclude with our official recommendation that AQR adopt the Gross Profit plus Value strategy.***

References

Asness, C. S., Moskowitz, T. J., & Pedersen, L. H. (2013). Value and Momentum Everywhere. The Journal of FINANCE, LXVIII(3), 929–985.

Canaday, T. L. S. (2009, December 30). Making Sense Of Market Anomalies. Retrieved from https://www.investopedia.com/articles/stocks/08/market-anomaly-efficient-market.asp

Kenton, W. (2018, July 10). Market Efficiency. Retrieved from https://www.investopedia.com/terms/m/marketefficiency.asp

Novy-Marx, R. (2013). The other side of value: The gross profitability premium. The Journal of Financial Economics, 108(2013), 1–28.