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## Relative Strength Strategies for Investing

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### ABSTRACT

The purpose of this paper is to present simple quantitative methods that improve risk-adjusted returns for investing in US equity sector and global asset class portfolios. A relative strength model is tested on the French-Fama US equity sector data back to the 1920s that results in increased absolute returns with equity-like risk. The relative strength portfolios outperform the buy and hold benchmark in approximately 70% of all years and returns are persistent across time. The addition of a trendfollowing parameter to dynamically hedge the portfolio decreases both volatility and drawdown. The relative strength model is then tested across a portfolio of global asset classes with supporting results.

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## MOMENTUM

Momentum based strategies, in which we group both trendfollowing and relative strength techniques, have been applied as investment strategies for over a century. Momentum has been one of the most widely discussed and researched investment strategies (some academics would prefer the term “anomaly”).

This paper is not an attempt to summarize the momentum literature. There are numerous sources that have done a fine job on that front already including:

[On the Nature and Origins of Trendfollowing](#) – Stig Ostgaard

[The Case for Momentum Investing](#) – AQR Website

[Bringing Real World Testing to Relative Strength](#) – John Lewis

[Global Investment Returns Yearbook](#) – Dimson, Marsh, Staunton

Appendix in [Smarter Investing in Any Economy](#) – Michael Carr

[Trendfollowing](#) – Michael Covel

[The Capitalism Distribution](#) – BlackStar Funds

[Annotated Bibliography of Selected Momentum Research Papers](#) – AQR Website

Nor is this paper an attempt to publish an original and unique method for momentum investing. Similar systems and techniques to those that follow in this paper have been utilized for decades. Rather, our intent is to describe some simple methods that an everyday investor can use to implement momentum models in trading. The focus is on the practitioner with real world applicability.

## DATA

This research report utilizes the French-Fama CRSP [Data Library](#) since it has the longest history and is widely relied upon and accepted in the research community. Specifically, we are using the 10 Industry Portfolios with monthly returns from July 1926 through December 2009, encompassing over eight decades of US equity sector returns. Our study begins in 1928 since a year is needed for a ranking period. We utilize the value weighted groupings rather than the less realistic equal weighted portfolios, and the sectors are described below:

**Consumer Non-Durables** -- Food, Tobacco, Textiles, Apparel, Leather, Toys

**Consumer Durables** -- Cars, TV's, Furniture, Household Appliances

**Manufacturing** -- Machinery, Trucks, Planes, Chemicals, Office Furniture, Paper, Commercial Printing

**Energy** -- Oil, Gas, and Coal Extraction and Products

**Technology** -- Computers, Software, and Electronic Equipment

**Telecommunications** -- Telephone and Television Transmission

**Shops** -- Wholesale, Retail, and Some Services (Laundries, Repair Shops)

**Health** -- Healthcare, Medical Equipment, and Drugs

**Utilities**

**Other** -- Mines, Construction, Transportation, Hotels, Business Services, Entertainment, Finance

Data for the global asset classes are obtained from Global Financial Data and described in the Appendix.

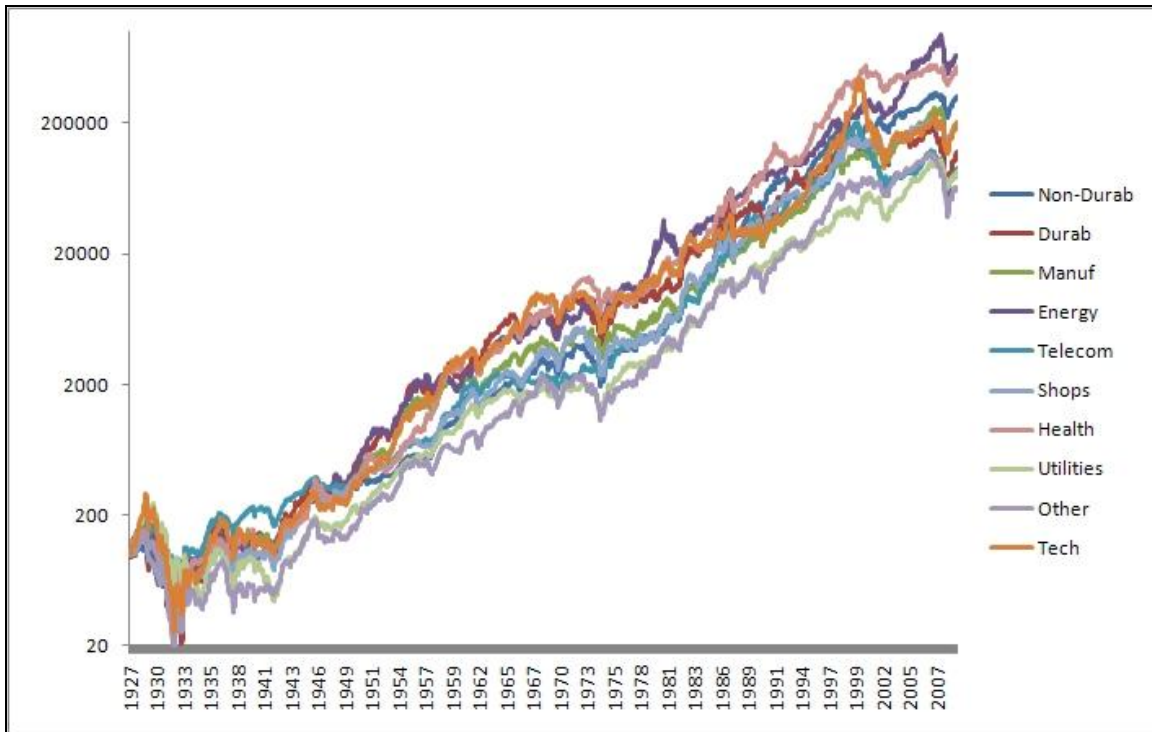
## SECTOR RETURNS

In the United States the 20<sup>th</sup> Century experienced strong returns for an equity investor.

**Exhibit 1 – US Equity Sector Total Returns, 1928-2009**

BUY AND HOLD	Non-Durab	Durab	Manuf	Energy	Tech
CAGR	10.35%	9.04%	9.74%	11.30%	9.71%
STDEV	16.38%	27.06%	22.25%	20.95%	25.94%
SHARPE (3.81%)	0.40	0.19	0.27	0.36	0.23
MAXDD	(65.88%)	(90.07%)	(88.66%)	(75.66%)	(91.06%)
BUY AND HOLD	Telecom	Shops	Health	Utilities	Other
CAGR	8.66%	9.66%	11.03%	8.58%	8.20%
STDEV	16.22%	20.46%	20.11%	19.79%	22.88%
SHARPE (3.81%)	0.30	0.29	0.36	0.24	0.19
MAXDD	(71.89%)	(84.14%)	(74.94%)	(85.90%)	(90.28%)

**Exhibit 2 – US Equity Sector Total Returns, 1928-2009**



For comparison we have included a portfolio that is equal weighted among the ten sectors, rebalanced monthly, as well as the S&P 500.

**Exhibit 3 – US Equity Total Returns, 1928-2009**

BUY AND HOLD	S&P500	Equal Weight
CAGR	9.39%	10.28%
STDEV	19.39%	18.38%
SHARPE (3.81%)	0.29	0.35
MAXDD	(83.66%)	(81.67%)

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Investors received strong returns for equities, but they were not without risk. Volatility and massive drawdowns were commonplace. Below we will examine a method for momentum investing, specifically relative strength.

Below are the buy and sell rules for the system.

## **RANKING**

Each month the ten sectors are ranked on trailing total return including dividends. We use varying periods of measurement ranging from one to twelve months, as well as a combination of multiple months.

For example: If we are examining relative strength at the one month interval on December 31<sup>st</sup> 2009, we would simply sort the ten sectors by their prior month (December 2009) total returns including dividends. For the three month period, we would sort the ten sectors by their three month (October 2009-December 2009) total returns including dividends.

## **BUY RULE**

The system invests in the top X sectors. For Top 1, the system is 100% invested in the top ranked sector. For Top 2, the system is 50% invested in each of the top two sectors. For Top 3, the system is 33% invested in each of the top three sectors.

## **SELL RULE**

Since the system is a simple ranking, the top X sectors are held and if a sector falls out of the top X sectors it is sold at the monthly rebalance and replaced with the sector in the top X.

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1. All entry and exit prices are on the day of the signal at the close. The model is only updated once a month on the last day of the month. Price fluctuations during the rest of the month are ignored.
  2. All data series are total return series including dividends, updated monthly.
  3. Taxes, commissions, and slippage are excluded (see the Real World Implementation section later in the paper).

Below are summaries of the various ranking periods and returns for the portfolios. The 1, 3, 6, 9, and 12 month combination simply takes an average of the five rolling returns for each sector every month to sort the 10 sectors.



### Exhibit 4.1 – 1 Month Relative Strength Portfolios, 1928-2009

	Top1	Top2	Top3	Top4	Top5	Top6	Top7	Top8	Top9	EQ-Weight
CAGR	12.63%	13.74%	14.43%	13.88%	12.91%	12.47%	12.01%	11.85%	11.22%	10.28%
STDEV	23.00%	20.46%	19.79%	19.17%	18.81%	18.80%	18.62%	18.51%	18.43%	18.38%
SHARPE (3.81%)	0.38	0.49	0.54	0.53	0.48	0.46	0.44	0.43	0.40	0.35
MAXDD	(81.69%)	(74.21%)	(74.65%)	(76.36%)	(76.53%)	(78.31%)	(78.66%)	(79.49%)	(80.62%)	(81.67%)

### Exhibit 4.2 – 3 Month Relative Strength Portfolios, 1928-2009

	Top1	Top2	Top3	Top4	Top5	Top6	Top7	Top8	Top9	EQ-Weight
CAGR	13.32%	13.83%	13.44%	13.08%	12.43%	11.79%	11.40%	10.84%	10.62%	10.28%
STDEV	20.79%	19.52%	18.55%	18.40%	18.29%	18.07%	18.14%	18.15%	18.38%	18.38%
SHARPE (3.81%)	0.46	0.51	0.52	0.50	0.47	0.44	0.42	0.39	0.37	0.35
MAXDD	(64.50%)	(70.20%)	(73.92%)	(75.80%)	(77.52%)	(79.23%)	(78.92%)	(80.29%)	(80.57%)	(81.67%)

### Exhibit 4.3 – 6 Month Relative Strength Portfolios, 1928-2009

	Top1	Top2	Top3	Top4	Top5	Top6	Top7	Top8	Top9	EQ-Weight
CAGR	12.86%	14.10%	13.18%	12.60%	12.51%	11.72%	11.62%	11.01%	10.71%	10.28%
STDEV	21.60%	19.20%	18.29%	18.02%	17.87%	17.77%	17.87%	18.01%	18.24%	18.38%
SHARPE (3.81%)	0.42	0.54	0.51	0.49	0.49	0.45	0.44	0.40	0.38	0.35
MAXDD	(90.53%)	(84.30%)	(80.97%)	(76.81%)	(76.19%)	(77.68%)	(77.87%)	(78.86%)	(80.41%)	(81.67%)

### Exhibit 4.4 – 9 Month Relative Strength Portfolios, 1928-2009

	Top1	Top2	Top3	Top4	Top5	Top6	Top7	Top8	Top9	EQ-Weight
CAGR	14.80%	14.17%	12.60%	12.28%	12.07%	11.80%	11.48%	11.13%	10.74%	10.28%
STDEV	22.21%	19.70%	19.00%	18.59%	18.36%	18.29%	18.06%	18.14%	18.22%	18.38%
SHARPE (3.81%)	0.50	0.53	0.46	0.46	0.45	0.44	0.42	0.40	0.38	0.35
MAXDD	(83.52%)	(75.94%)	(72.53%)	(75.26%)	(76.35%)	(76.86%)	(77.56%)	(79.10%)	(81.35%)	(81.67%)

### Exhibit 4.5 – 12 Month Relative Strength Portfolios, 1928-2009

	Top1	Top2	Top3	Top4	Top5	Top6	Top7	Top8	Top9	EQ-Weight
CAGR	16.05%	14.75%	13.94%	13.41%	12.96%	12.50%	11.67%	11.48%	10.82%	10.28%
STDEV	21.79%	19.57%	18.38%	18.18%	17.92%	17.87%	17.94%	18.16%	18.23%	18.38%
SHARPE (3.81%)	0.56	0.56	0.55	0.53	0.51	0.49	0.44	0.42	0.39	0.35
MAXDD	(76.91%)	(76.27%)	(71.29%)	(74.01%)	(74.18%)	(74.23%)	(77.70%)	(79.72%)	(81.07%)	(81.67%)



**Exhibit 4.6 – Combination 1, 3, 6, 9 and 12 Month Relative Strength Portfolios, 1928-2009**

	Top1	Top2	Top3	Top4	Top5	Top6	Top7	Top8	Top9	EQ-Weight
CAGR	16.13%	14.87%	13.75%	13.08%	12.68%	12.47%	12.19%	11.47%	10.78%	10.28%
STDEV	21.74%	19.16%	18.45%	18.17%	18.14%	18.22%	18.30%	18.18%	18.31%	18.38%
SHARPE (3.81%)	0.57	0.58	0.54	0.51	0.49	0.48	0.46	0.42	0.38	0.35
MAXDD	(77.21%)	(77.96%)	(72.65%)	(73.26%)	(75.63%)	(75.82%)	(76.78%)	(79.54%)	(81.07%)	(81.67%)
BEST YEAR	95.33%	105.28%	89.18%	65.50%	60.65%	62.53%	65.98%	55.96%	57.89%	53.38%
WORST YEAR	(31.64%)	(31.30%)	(31.73%)	(30.70%)	(30.47%)	(30.14%)	(32.83%)	(35.01%)	(36.70%)	(38.21%)
% YEARS OUT	73.17%	70.73%	67.07%	71.95%	75.61%	73.17%	76.83%	74.39%	67.07%	-
Turnover	378%	331%	281%	235%	190%	197%	150%	119%	86%	0%

From the above tables it is apparent that the relative strength method works on all of the measurement periods from one month to twelve months, as well as a combination of the 1, 3, 6, 9, and 12 month time periods. More interesting is that the system outperforms buy and hold in roughly 70% of all years. Below is an equity curve for the combination measurement system. A rough estimate of 300-600 basis points of outperformance per year is reasonable.

Exhibit 5 – Relative Strength Portfolios, 1928-2009

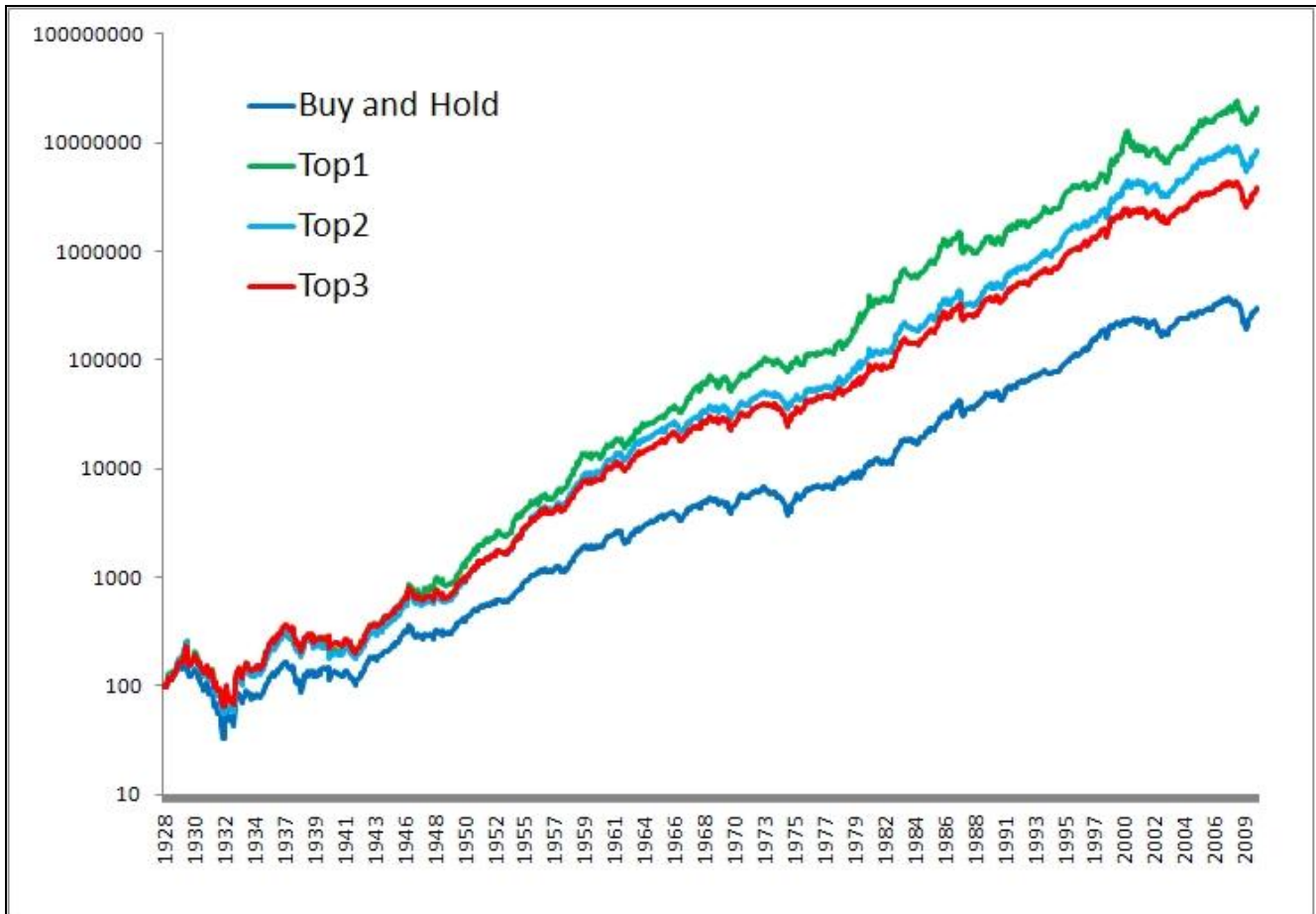


Exhibit 6 shows the outperformance by decade for the relative strength strategy on a yearly compounded basis. For example, the Top 1 beat the buy and hold portfolio by 2.68% a year in the 1930s.

**Exhibit 6 – Relative Strength Portfolios, CAGR Outperformance by Decade 1928-2009**

	Top 1	Top 2	Top 3
1930s	2.68%	2.61%	4.12%
1940s	5.61%	3.21%	2.00%
1950s	11.29%	9.77%	7.06%
1960s	8.11%	5.68%	4.19%
1970s	5.16%	2.29%	1.94%
1980s	2.27%	0.82%	1.14%
1990s	6.50%	6.65%	3.74%
2000s	3.85%	4.86%	1.76%
<b>Average</b>	<b>5.68%</b>	<b>4.48%</b>	<b>3.24%</b>

## SOLUTIONS TO THE DRAWBACKS OF RELATIVE STRENGTH SYSTEMS

The biggest drawback of a relative strength system is that the portfolio is long-only and fully invested, thus leaving the portfolio exposed to the risks of that particular asset beta. In this case the investor is exposed primarily to US stock risk. This detail can be seen in the volatility and drawdowns of all of the portfolios.

There are two possible solutions to control for the losses and drawdowns while using a relative strength rotation system: (1) hedging and, (2) adding non-correlated asset classes.

**Solution 1: Hedging (either moving to cash or hedging with shorts).** Hedging can be done on a sector basis or on a portfolio wide asset class basis. An investor could utilize a static hedge that always hedges a percentage of the portfolio, or possibly the entire portfolio (market neutral). This hedging technique has the drawback of hedging the portfolio when the market is appreciating, but also protects against all declines and shocks. An

investor could also use options to gain short exposure (essentially acting as insurance), with a cost, to the portfolio.

Another hedging option is a dynamic hedging technique that attempts to hedge when conditions are more favorable to market declines. Consistent with research we published in "[A Quantitative Approach to Tactical Asset Allocation](#)", using a long term moving average to hedge a portfolio results in a reduction in volatility and drawdown versus buy and hold. This approach can be seen in this research piece we published on trading Fidelity Sector Funds, "[Combining Rotation and Timing Systems](#)". Below we examine the combination of the 1, 3, 6, 9, and 12 month sector rotation portfolios when they are dynamically hedged. The portfolios move entirely to 100% cash (T-Bills) when the S&P 500 is below its 10 month Simple Moving Average (SMA). (Note: This system could also be run individually on the sectors with similar results.)

**Exhibit 7 – Dynamically Hedged Combination 1, 3, 6, 9 and 12 Month  
Relative Strength Portfolios, 1928-2009**

	Top1	Top2	Top3	Top4	Top5	Top6	Top7	Top8	Top9	EQ-Weight
CAGR	14.67%	14.42%	13.28%	12.53%	12.38%	11.94%	11.61%	11.10%	10.75%	10.40%
STDEV	17.94%	15.32%	14.26%	15.21%	13.48%	13.02%	12.77%	12.51%	12.32%	12.14%
SHARPE (3.81%)	0.61	0.69	0.66	0.57	0.64	0.63	0.61	0.58	0.56	0.54
MAXDD	(54.69%)	(51.36%)	(49.42%)	(54.65%)	(48.55%)	(45.74%)	(43.69%)	(43.29%)	(42.20%)	(42.27%)

By adding the dynamic hedge, most portfolios preserve their returns (although the Top 1 takes a 150 basis point hit), but have the added benefit of reduced volatility and drawdowns. While an approximate 40-50% drawdown is still large, it is more tolerable than a 70-80% drawdown.

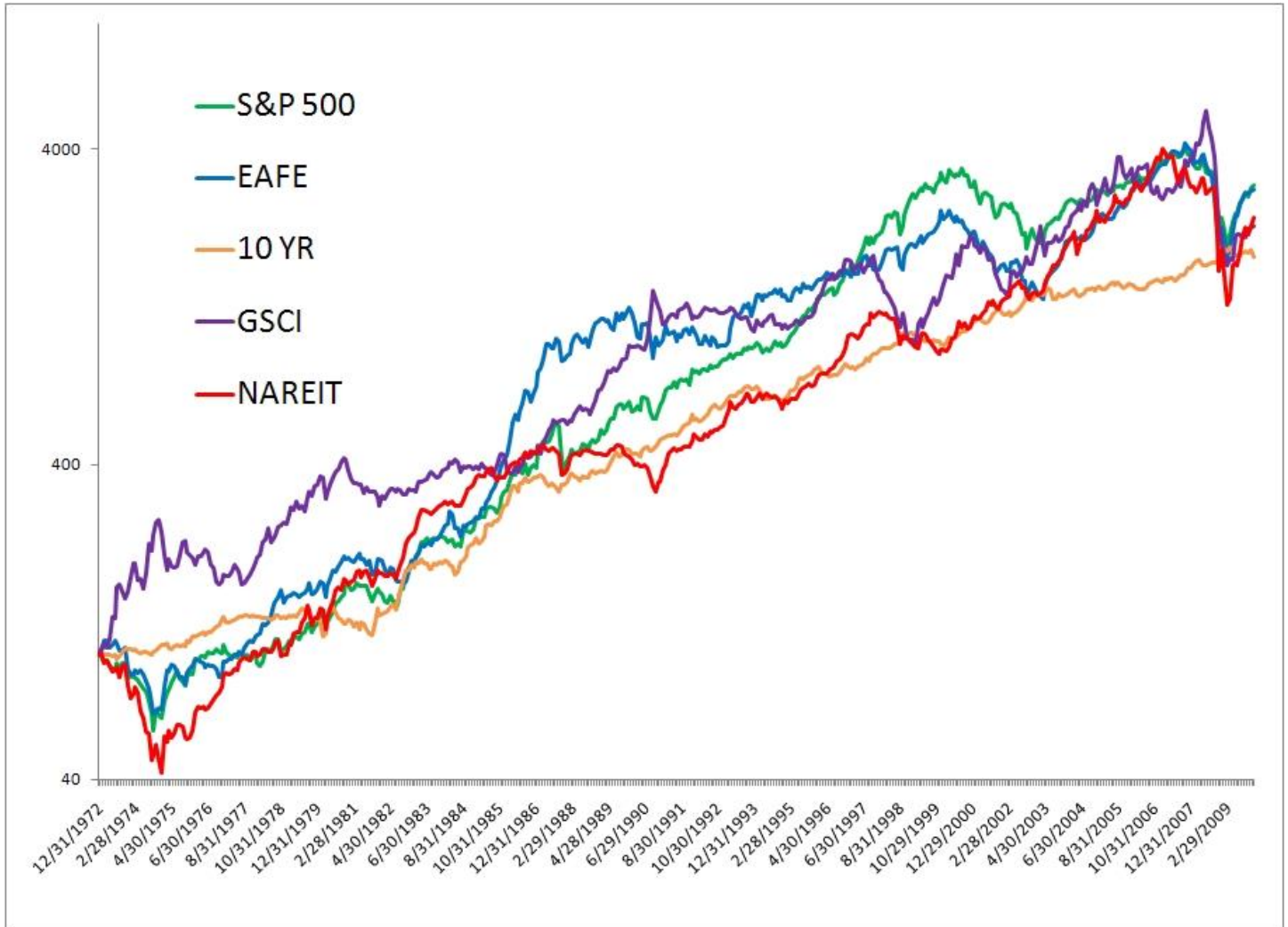
**Solution 2: Addition of non-correlated asset classes.** The second possible solution to the drawback of single asset class exposure inherent in the US sector rotation strategy is to add non-correlated global asset classes to the portfolio. Just as we have demonstrated above that a momentum strategy works in US equity sectors, so too does momentum work across global asset classes. We detailed this method in our book [The Ivy Portfolio](#) with a global rotation system that adds foreign stocks, bonds, REITs, and commodities to the portfolio. Other asset classes and spreads could be included to further diversify the portfolio, but examining this simple five asset class portfolio is instructive.

Below are the returns of the five asset classes we examine in this paper since 1973. The buy and hold benchmark is an equal-weighted portfolio of the five asset classes, rebalanced monthly.

**Exhibit 8 – Global Asset Class Total Returns, 1973-2009**

	BUY & HOLD	S&P 500	EAFE	10 YR	GSCI	NAREIT
CAGR	10.01%	9.69%	9.62%	8.16%	8.82%	9.02%
STDEV	10.15%	15.75%	17.45%	9.07%	20.57%	18.23%
SHARPE (5.9%)	0.41	0.24	0.21	0.25	0.14	0.17
MAXDD	(46.02%)	(50.77%)	(56.40%)	(18.79%)	(67.64%)	(67.88%)

**Exhibit 9 – Global Asset Class Total Returns, 1973-2009**



Below are summaries of the various ranking periods and returns for the portfolios.



**Exhibit 10.1 – 1 Month Relative Strength Portfolios, 1973-2009**

	Top 1	Top 2	Top 3	Top 4	BUY & HOLD
CAGR	17.01%	14.79%	12.74%	10.93%	10.02%
STDEV	17.19%	12.26%	10.92%	10.60%	10.15%
SHARPE (5.9%)	0.65	0.72	0.63	0.47	0.41
MAXDD	(22.41%)	(29.39%)	(33.15%)	(44.04%)	(46.02%)

**Exhibit 10.2 – 3 Month Relative Strength Portfolios, 1973-2009**

	Top 1	Top 2	Top 3	Top 4	BUY & HOLD
CAGR	14.27%	13.23%	13.01%	10.72%	10.02%
STDEV	18.97%	12.75%	10.75%	10.40%	10.16%
SHARPE (5.9%)	0.44	0.58	0.66	0.46	0.41
MAXDD	(43.02%)	(31.46%)	(38.67%)	(41.85%)	(46.02%)

**Exhibit 10.3 – 6 Month Relative Strength Portfolios, 1973-2009**

	Top 1	Top 2	Top 3	Top 4	BUY & HOLD
CAGR	13.55%	16.13%	12.92%	10.87%	10.02%
STDEV	19.08%	12.29%	10.91%	10.28%	10.16%
SHARPE (5.9%)	0.40	0.83	0.64	0.48	0.41
MAXDD	(50.19%)	(34.22%)	(40.22%)	(43.63%)	(46.02%)

**Exhibit 10.4 – 9 Month Relative Strength Portfolios, 1973-2009**

	Top 1	Top 2	Top 3	Top 4	BUY & HOLD
CAGR	15.31%	15.00%	14.31%	11.20%	10.02%
STDEV	18.73%	12.77%	10.93%	10.57%	10.16%
SHARPE (5.9%)	0.50	0.71	0.77	0.50	0.41
MAXDD	(38.91%)	(35.14%)	(39.84%)	(43.34%)	(46.02%)



**Exhibit 10.5 – 12 Month Relative Strength Portfolios, 1973-2009**

	Top 1	Top 2	Top 3	Top 4	BUY & HOLD
CAGR	15.41%	14.83%	13.32%	11.48%	10.02%
STDEV	18.89%	12.64%	11.05%	10.70%	10.15%
SHARPE (5.9%)	0.50	0.71	0.67	0.52	0.41
MAXDD	(48.74%)	(39.65%)	(43.56%)	(46.82%)	(46.02%)

**Exhibit 10.6 – Combination 1, 3, 6, 9, and 12 Month Relative Strength Portfolios, 1973-2009**

	Top 1	Top 2	Top 3	Top 4	BUY & HOLD
CAGR	16.30%	16.47%	14.49%	11.06%	10.02%
STDEV	18.58%	12.62%	11.00%	10.47%	10.15%
SHARPE (5.9%)	0.56	0.84	0.78	0.49	0.41
MAXDD	(30.87%)	(33.38%)	(39.84%)	(47.20%)	(46.02%)
BEST YEAR	74.96%	37.89%	36.08%	32.46%	26.58%
WORST YEAR	(15.18%)	(8.63%)	(22.26%)	(31.07%)	(30.09%)
% YEARS OUT	70.27%	70.27%	78.38%	59.46%	-

From the above tables it is apparent that the relative strength method works on all of the measurement periods from one month to twelve months, as well as a combination of time periods. More interesting is that the system outperforms buy and hold in roughly 70% of all years. A rough estimate of 300-600 basis points of outperformance per year is reasonable. Below is an equity curve:

**Exhibit 11 – Combination 1, 3, 6, 9, and 12 Month Relative Strength Portfolios, 1973-2009**

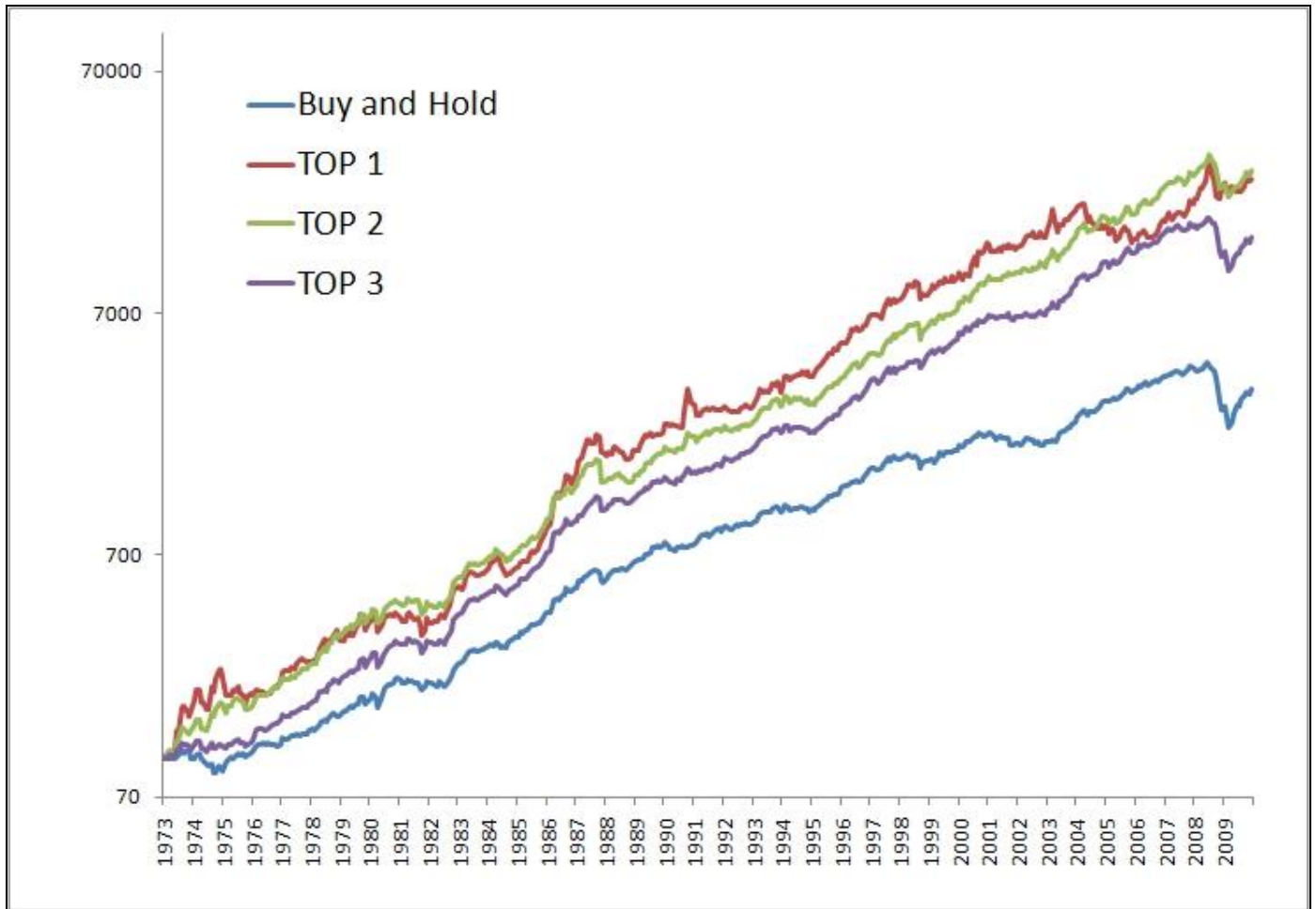


Exhibit 12 shows the outperformance by decade for the relative strength strategy on a yearly compounded basis.

For example, the Top 1 beat the buy and hold portfolio by 6% a year in the 1990s.

**Exhibit 12 – Combination 1, 3, 6, 9, and 12 Month Relative Strength Portfolios, CAGR Outperformance  
by Decade 1973-2009**

	TOP 1	TOP 2	TOP 3
1970s	11.98%	12.94%	5.94%
1980s	4.70%	1.46%	3.04%
1990s	5.75%	4.96%	5.00%
2000s	4.46%	8.28%	4.29%
<b>Average</b>	<b>6.72%</b>	<b>6.91%</b>	<b>4.57%</b>

What about combination both solutions? Below we report the results of rotation among global asset classes but only investing in the asset class if it is trading above its 10 month SMA (otherwise that portion is invested in T-Bills).

The results are slightly improved Sharpe Ratios and similar absolute returns, but with marked reductions in drawdown. The effect is most seen in the portfolios that utilized more asset classes.

**Exhibit 10.6 – Combination 1, 3, 6, 9, and 12 Month Relative Strength Portfolios, 1973-2009**

	Top 1	Top 2	Top 3	Top4	BUY & HOLD
CAGR	15.97%	16.50%	15.00%	12.94%	10.02%
STDEV	18.40%	11.94%	9.60%	8.14%	10.15%
SHARPE (5.9%)	0.55	0.89	0.95	0.86	0.41
MAXDD	(31.17%)	(21.67%)	(12.95%)	(12.46%)	(46.02%)
BEST YEAR	74.96%	38.04%	36.08%	32.46%	26.58%
WORST YEAR	(15.18%)	(1.21%)	(3.49%)	(1.10%)	(30.09%)
% YEARS OUT	72.97%	72.97%	78.38%	64.86%	-

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## REAL WORLD IMPLEMENTATION

While this paper is meant to be an instructive base case scenario, care must be observed when translating theory into real world trading. While most industries over the period examined were represented by a robust amount of underlying companies, a few (Telecom and Health specifically) had less than twenty companies until the 1950s. The persistence of the momentum strategy by decade goes to show that this was not simply a property of markets 80 years ago, but continues to work today.

Obviously US sector funds did not exist in the 1920s. Attempting to transact in shares of the underlying companies would have been far too expensive to actively manage the portfolio in the early part of the 20<sup>th</sup> Century as turnover of 100% to 400% is very high for transactions in exchange traded securities. However, even assuming a round trip cost of 1% to the portfolio would still allow for excess momentum profits to the portfolios.

The practitioner today can choose from thousands of mutual funds, ETFs, and closed-end funds. Many of these funds can be traded for \$8 a trade or less, and many mutual funds and ETFs are now commission free at some online brokers. Mutual funds also avoid any bid ask spread and market impact costs, but also typically have higher management fees than ETFs and can be subject to redemption fees if held for short periods of time (many Fidelity funds require a holding period of 30 days). Some ETFs can be painfully illiquid so care must be taken when selecting funds.

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To reduce trading frequency and possible transaction costs an investor could implement a sell filter. Assuming a universe of ten funds, the investor could buy the top three funds and sell them when the funds drop out of the top five funds. This approach would lower the turnover to sub-100% levels.

As with any strategy, taxes are a very real consideration and the strategy should be traded in a tax deferred account. It is difficult to estimate the impact an investor would experience due to varying tax rates by income bracket and over time, but an increase from 5-20% turnover to 70-100% turnover could result in an increase in taxes of 50-150 bps.

## **CONCLUSION**

The purpose of this paper was to demonstrate a simple-to-follow method for utilizing relative strength in investing in US equities and global asset classes. The results showed robust performance across measurement periods as well as over the past eight decades. While absolute returns were improved, volatility and drawdown remained high. Various methods were examined that could be used as solutions to a long only rotation system including hedging and adding non-correlated asset classes.

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## APPENDIX A - DATA SOURCES

From the French-Fama website:

### Detail for 10 Industry Portfolios

**Daily Returns:** July 1, 1963-December 31, 2009

**Monthly Returns:** July 1926-December 2009

**Annual Returns:** 1927-2009

**Portfolios:** [Download industry definitions](#)

We assign each NYSE, AMEX, and NASDAQ stock to an industry portfolio at the end of June of year  $t$  based on its four-digit SIC code at that time. (We use Compustat SIC codes for the fiscal year ending in calendar year  $t-1$ . Whenever Compustat SIC codes are not available, we use CRSP SIC codes for June of year  $t$ .) We then compute returns from July of  $t$  to June of  $t+1$ .

Fama and French update the research data at least once a year, but we may update them at other times. Unlike the benchmark portfolios, (1) we reform almost all these portfolios annually (UMD is formed monthly), (2) we do not include a hold range, and (3) we ignore transaction costs. In addition, we reconstruct the full history of returns each time we update the portfolios. (Historical returns can change, for example, if CRSP revises its database.) Although the portfolios include all NYSE, AMEX, and NASDAQ firms with the necessary data, the breakpoints use only NYSE firms.

S&P 500 Index – A capitalization-weighted index of 500 stocks that is designed to mirror the performance of the United States economy. Total return series is provided by Global Financial Data and results pre-1971 are constructed by GFD. Data from 1900-1971 uses the S&P Composite Price Index and dividend yields supplied by the Cowles Commission and from S&P itself.

MSCI EAFE Index (Europe, Australasia, Far East) – A free float-adjusted market capitalization index that is designed to measure the equity market performance of developed markets, excluding the US and Canada. As of June 2007 the MSCI EAFE Index consisted of the following 21 developed market country indices: Australia, Austria, Belgium, Denmark, Finland, France, Germany, Greece, Hong Kong, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Singapore, Spain, Sweden, Switzerland, and the United Kingdom. Total return series is provided by Morgan Stanley.

U.S. Government 10-Year Bonds – Total return series is provided by Global Financial Data.

Goldman Sachs Commodity Index (GSCI) – Represents a diversified basket of commodity futures that is unlevered and long only. Total return series is provided by Goldman Sachs.

National Association of Real Estate Investment Trusts (NAREIT) – An index that reflects the performance of publicly traded REITs. Total return series is provided by the NAREIT.