A Quantitative Approach to Tactical Asset Allocation

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ABSTRACT

The purpose of this paper is to present a simple quantitative method that improves the risk-adjusted returns across various asset classes. A simple moving average timing model is tested since 1900 on the United States equity market before testing since 1973 on other diverse and publicly traded asset class indices, including the Morgan Stanley Capital International EAFE Index (MSCI EAFE), Goldman Sachs Commodity Index (GSCI), National Association of Real Estate Investment Trusts Index (NAREIT), and United States government 10-year Treasury bonds. The approach is then examined in a tactical asset allocation framework where the empirical results are equity-like returns with bond-like volatility and drawdown.

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Updates included in the 2009 paper:

1. Results are extended out-of-sample to include the years 2006, 2007, and 2008.
2. Results begin in 1973 instead of 1972 to accommodate longer moving averages.
3. Sharpe calculations are corrected (T-bill returns over time period vs. static figure).
4. Additional commentary and statistics are included.
5. Volatility figures now use the annualized standard deviation of monthly returns.

INVESTING IN RISKY ASSETS

2008 was a devastating year for buy and hold investors. The classic barometer of stocks, the S&P 500 Index, declined 36.77%. The normal benefits of diversification disappeared as many non-correlated asset classes experienced large declines simultaneously. Commodities, REITs, and foreign stock indices all suffered losses over 35%.

While many global asset classes in the twentieth century produced spectacular gains in wealth for individuals who bought and held those assets for generation-long holding periods,[1] most common asset classes experienced regular and painful drawdowns.[2] All of the G-7 countries experienced at least one period where stocks lost 75% of their value. The unfortunate mathematics of a 75% decline require an investor to realize a 300% gain just to get back to even – the equivalent of compounding at 10% for 15 years.

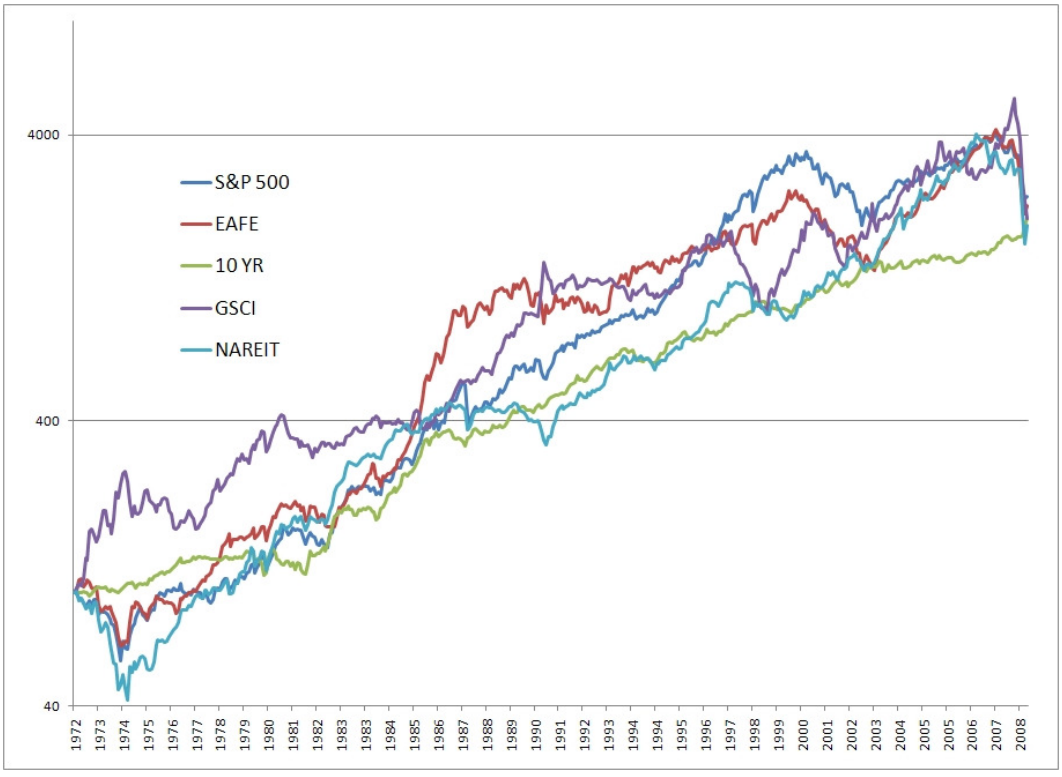
Individuals invested in U.S. stocks in the late 1920s and early 1930s, German asset classes in the 1910s and 1940s, U.S. real estate in the mid-1950s, Japanese stocks in the late 1980s, emerging markets and commodities in the late 1990s, and nearly everything in 2008, would reason that holding these assets was a decidedly unwise course of action. Most individuals do not have a sufficiently long time frame to recover from large drawdowns from risky asset classes.

[1] See *Triumph of the Optimists*.

[2] Drawdown is the peak-to-trough decline an investor would experience in an investment, and we calculate it here on a monthly basis.

Modern portfolio theory holds that there is a tradeoff for investing in assets – you get paid to assume risk. Exhibit 1 shows the five asset classes we will examine in this paper: U.S. stocks (S&P 500), foreign stocks (MSCI EAFE), commodities (GSCI), REITs (NAREIT), United States government 10-year Treasury bonds (10 YR), and their returns since 1973. While they took different routes to get there, most of the asset classes finished with similar returns over the time period. The exception was bonds, which trailed the other asset classes, an outcome that is to be expected due to their lower volatility and risk. The fact that bonds were even close in absolute performance to the other equity-like asset classes reflects the greater-than-twenty-year bull market that took yields from double-digit levels to near zero today.

Exhibit 1 - Asset Class Returns 1973-2008, log scale



Source: Data sources are cited at the end of the article.

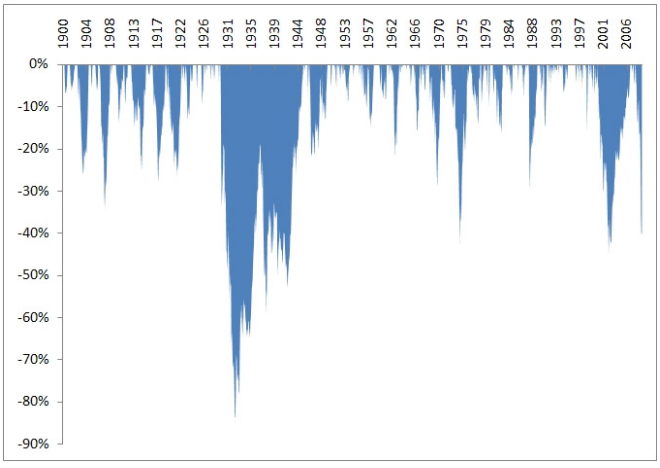
Exhibit 2 shows that, while these are some pretty nice returns, they are coupled with some large drawdowns. With the exception of U.S. government bonds, which declined almost 20% the other four asset classes had drawdowns around 40% to 60%. If an investor were to take the data back further, those drawdowns only get bigger[3].

Exhibit 2 - Asset Class Maximum Drawdowns 1973-2008

	S&P 500	EAFE	10 YR	GSCI	NAREIT
Return	9.26%	9.04%	8.69%	8.73%	8.54%
Volatility	15.54%	17.18%	9.06%	17.04%	17.06%
Sharpe (6%)	0.21	0.18	0.30	0.16	0.15
Max Drawdown	(44.73%)	(49.21%)	(18.79%)	(62.16%)	(58.78%)
Best Year	37.58%	69.94%	44.28%	74.96%	48.97%
Worst Year	(36.77%)	(43.06%)	(7.51%)	(46.49%)	(42.23%)

To give the reader a visual perspective of drawdowns, Exhibit 3 shows the drawdowns for stocks for the past 108 years. Drawdowns of 10%-20% are fairly frequent, with 30%-40% drawdowns less so. The large 1920s bear market dominates the figure with a drawdown over 80%.

Exhibit 3 – S&P 500 Drawdowns, 1900-2008



[3] Higher resolution daily data and longer lookback periods can only increase the drawdown amount.

The former manager of the Harvard endowment, Mohamed El-Erian recently stated, "Diversification alone is no longer sufficient to temper risk. In the past year, we saw virtually every asset class hammered. You need something more to manage risk well." (Kiplinger's 2009).

This paper will examine a very simple quantitative market timing model that manages risk. This trend-following model[4] is examined in-sample on the U.S. stock market since 1900 before out-of-sample testing across four other markets. The attempt is not to build an optimization model, but rather to build a simple trading model that works in the vast majority of markets. The results suggest that a market timing solution is a risk-reduction technique that signals when an investor should exit a risky asset class in favor of risk-free Treasury bills.

The approach is then examined in an allocation framework since 1973 where the empirical results are equity-like returns with bond-like volatility and drawdown.

THE QUANTITATIVE SYSTEM

In deciding on what logic to base this system on, there are a few criteria that are necessary for this model to be simple enough for investors to follow, and mechanical enough to remove emotion and subjective decision-making.

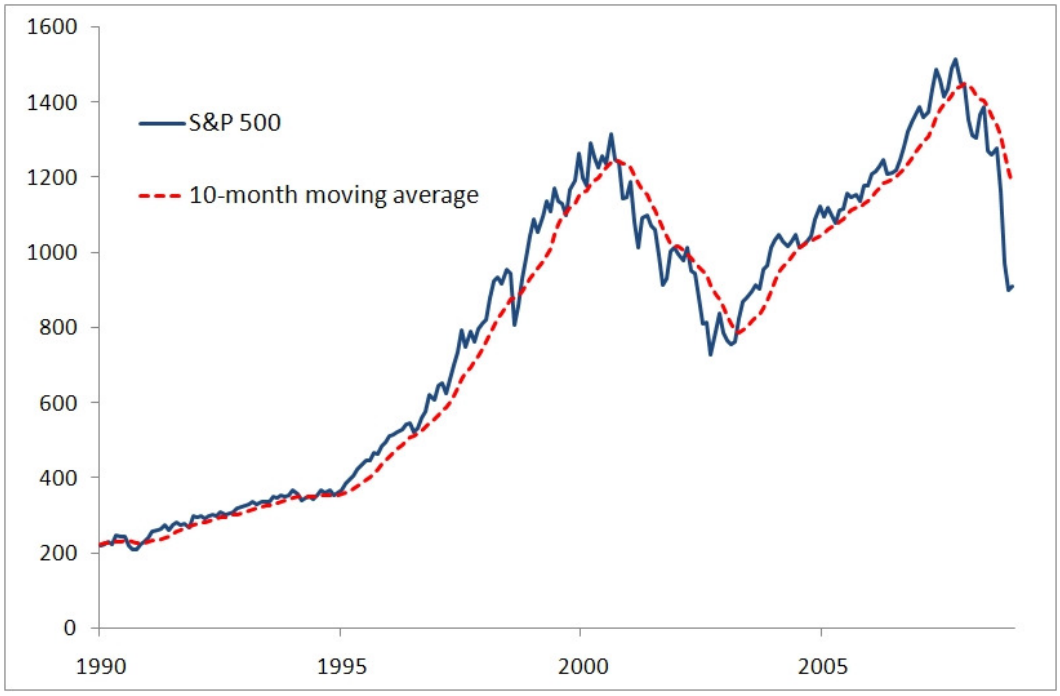
They are:

[4] Instead of offering a lengthy review of the momentum and trendfollowing literature here, the material is included in the Appendix.

1. Simple, purely mechanical logic.
2. The same model and parameters for every asset class.
3. Price-based only.

Moving-average-based trading systems are the simplest and most popular trend-following systems[5]. For those unfamiliar with moving averages, they are a way to reduce noise. The example below shows the S&P 500 with a 10-month simple moving average.

Exhibit 4 – S&P 500 vs. 10-Month Simple Moving Average, 1990-2008



The most often cited long-term measure of trend in the technical analysis community is the 200-day simple moving average (SMA). In his book *Stocks for the Long Run*, Jeremy Siegel (2008) investigates the use of the 200-day SMA in timing the Dow Jones

[5] Taylor and Allen (1992) and Lui and Mole (1998).

Industrial Average (DJIA) from 1886 to 2006. His test bought the DJIA when it closed at least 1 percent above the 200-day moving average, and sold the DJIA and invested in Treasury bills when it closed at least 1 percent below the 200-day moving average.

He concludes that market timing improves the absolute and risk-adjusted returns over buying and holding the DJIA. Likewise, when all transaction costs are included (taxes, bid-ask spreads, commissions), the risk-adjusted returns are still higher when employing market timing, though timing falls short on an absolute return measure. Had the results included 2008 they would favor timing even more.

When applied to the Nasdaq Composite Index since 1972, the market timing system thoroughly outperforms buy-and hold, both on an absolute and risk-adjusted basis. Siegel finds that the timing model outperforms buy and hold by over 4% per year from 1972-2006 even when accounting for all costs, and with 25% less volatility. Unfortunately, Siegel does not report drawdown figures, which would have further demonstrated the superiority of the timing model. (Note: Siegel's system is twice as active as the system presented in this paper, thus increasing the transaction costs).

Because we are privy to Siegel's results before conducting the test, this query should be seen as in-sample. It is possible that Siegel already optimized the moving average by looking back over the period in which it is then tested. To alleviate fears of data-mining, the approach will be applied out-of-sample to four other markets to test for validity.

The system is as follows:

BUY RULE

Buy when monthly price > 10-month SMA.

SELL RULE

Sell and move to cash when monthly price < 10-month SMA.

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. Cash returns are estimated with 90-day Treasury bills, and margin rates (for leveraged models to be discussed later) are estimated with the broker call rate.
4. Taxes, commissions, and slippage are excluded (see the Practical Considerations section later in the paper).

S&P 500 FROM 1900 - 2008

To demonstrate the logic and characteristics of the timing system, we test the S&P 500 back to 1900[6]. Exhibit 5 presents the annualized returns for the S&P 500 and the timing method for the past 100+ years. A cursory glance at the results reveals that the timing

[6] Total return series is provided by Global Financial Data and results pre-1971 are constructed by GFD. Data from 1900-1971 uses the Standard and Poor's Composite Price Index and dividend yields supplied by the Cowles Commission and from S&P itself.

solution improved compounded returns while reducing risk[7], all while being invested in the market approximately 70% of the time and making less than one round-trip trade per year.

Exhibit 5: S&P 500 Total Returns vs. Timing Total Returns (1900-2008)

	S&P 500	Timing
Annualized Return	9.21%	10.45%
Volatility	17.87%	12.01%
Sharpe (4%)	0.29	0.54
Maximum drawdown	(83.66%)	(50.31%)
Best Year	52.88%	52.40%
Worst Year	(43.86%)	(26.87%)

The timing system achieves these superior results while underperforming the index in roughly half of all years since 1900. One of the reasons for the overall outperformance is the lower volatility of the timing system. It is an established fact that high volatility diminishes compound returns. This principle can be illustrated by comparing average returns with compounded returns (the returns an investor would actually realize.) The average return for the S&P 500 since 1900 was 11.20%, while timing the S&P 500 returned 11.49%. However, the compounded returns for the two are 9.21% and 10.45%, respectively. Notice that the buy and hold crowd takes a hit of 199 basis points from the effects of volatility, while timing suffers a smaller decline of 104 basis points. Ed Easterling (2006) has a good discussion of these "volatility gremlins" in John Mauldin's Book, *Just One Thing*.

[7] Volatility is measured as the annualized standard deviation of monthly returns.

Exhibit 6 (logarithmic scale) shows the superiority of the timing model over the past century, largely avoiding the significant bear markets of the 1930s and 2000s. Timing would not have left the investor completely unscathed from the late 1920s early 1930s bear market, but it would have reduced the drawdown from a catastrophic 83.66% to a more manageable 42.24%.

Exhibit 6: S&P 500 Total Returns vs. Timing Total Returns (1900-2008)

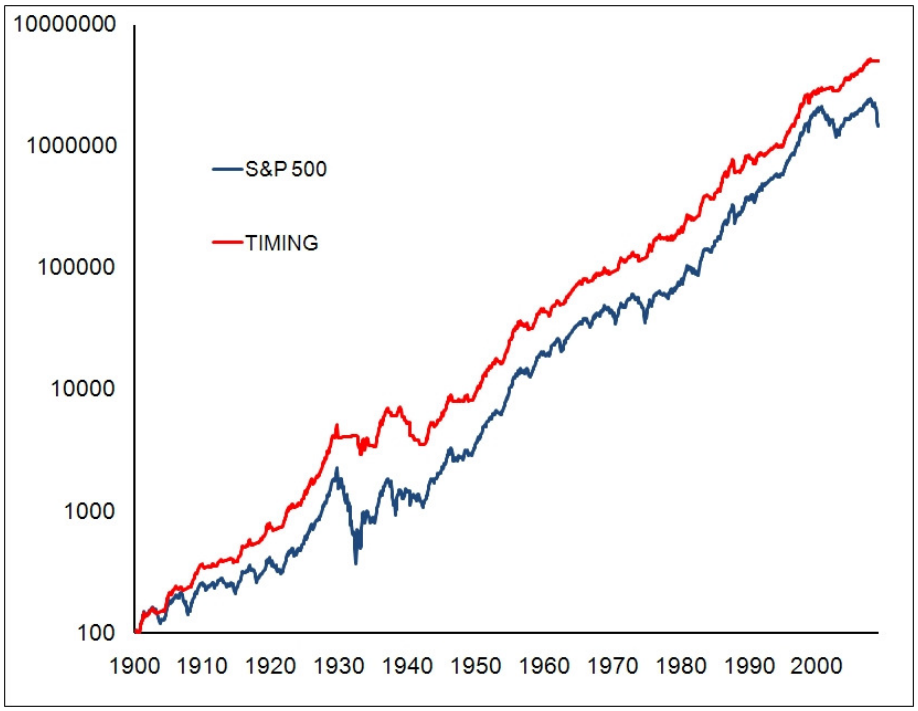
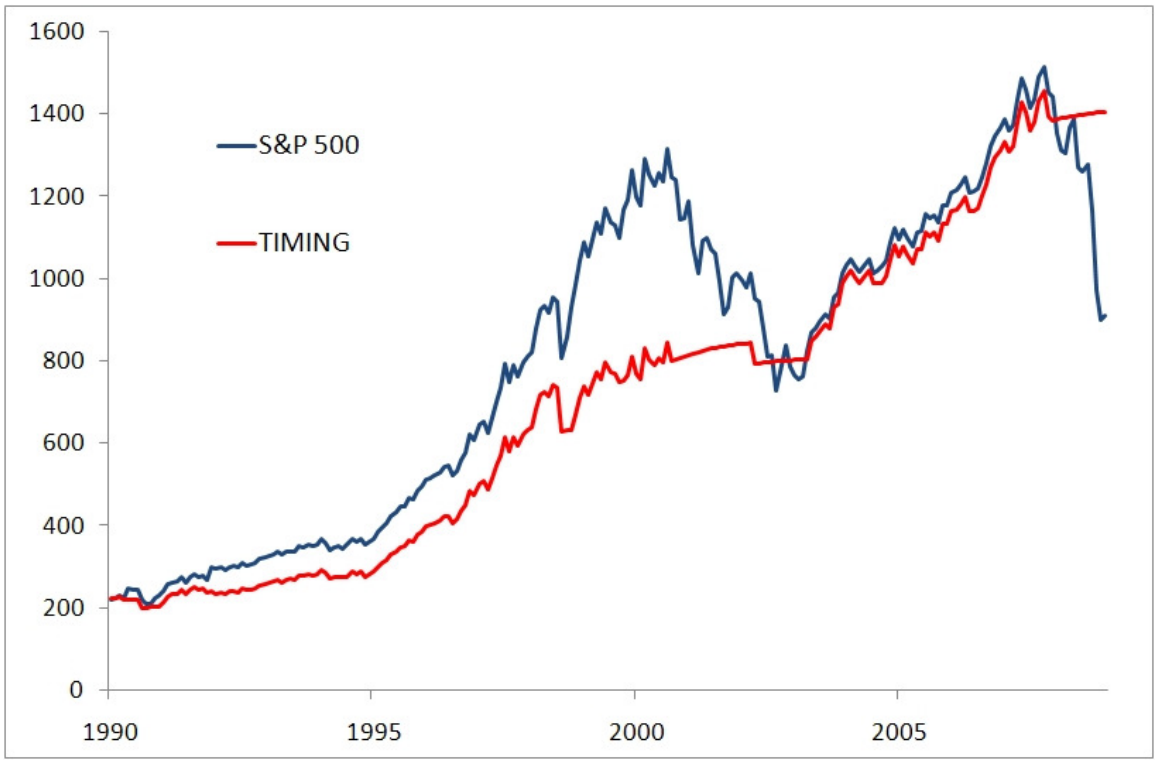


Exhibit 7 is charted on a non-log scale to detail the differences in the two equity curves. Examining the most recent 18 years, a few features of the timing model stand out**.** First, a trend-following model will underperform buy and hold during a roaring bull market similar to the U.S. equity markets in the 1990s. On the flip side, the timing model avoids lengthy and protracted bear markets. Consequently, the value added by timing is evident only over the course of entire business cycles.

For example, the timing model exits a long position in October of 2000, thus avoiding two of the three consecutive years of losses, and its 16.52% drawdown is much shallower than the 44.73% setback suffered by buy-and-hold investors. The timing model again exited the S&P 500 on December 31, 2007 and avoided the entire bear market of 2008.

Exhibit 7: S&P 500 Total Returns vs. Timing Total Returns (1990-2008)



A glance at Exhibit 8 presents the ten worst years for the S&P 500 for the past century, and the corresponding returns for the timing system. It is immediately obvious that the two do not move in lockstep. In fact, the correlation between negative years for the S&P 500 and the timing model is approximately -.37, while the correlation for all years is

approximately .82. This reflects the ability of the timing model to stay long in up markets while exiting the long position during down markets.

Exhibit 8: S&P 500 Ten Worst Years vs. Timing, 1900-2008

	S&P 500	TIMING
1931	(43.86%)	1.41%
2008	(36.77%)	1.33%
1937	(35.26%)	(7.65%)
1907	(29.61%)	(0.09%)
1974	(26.47%)	8.16%
1917	(25.26%)	(3.02%)
1930	(25.26%)	2.51%
2002	(22.10%)	(4.62%)
1920	(19.69%)	(4.80%)
1973	(14.69%)	(15.36%)

Exhibit 9 is the timing model excess returns over T-bills (rt - rf)[8], versus excess returns of buy and hold over T-bills (rm – rf). Just from the graph, it can be inferred that there exists a linear relationship for positive returns, while the negative returns are much more scattered.

[8] rt – timing return, rm – market return, rf – T-bill return.

Exhibit 9: S&P 500 Excess Returns (rm – rf) vs. Timing Excess Returns (rt-rf), 1900-2008

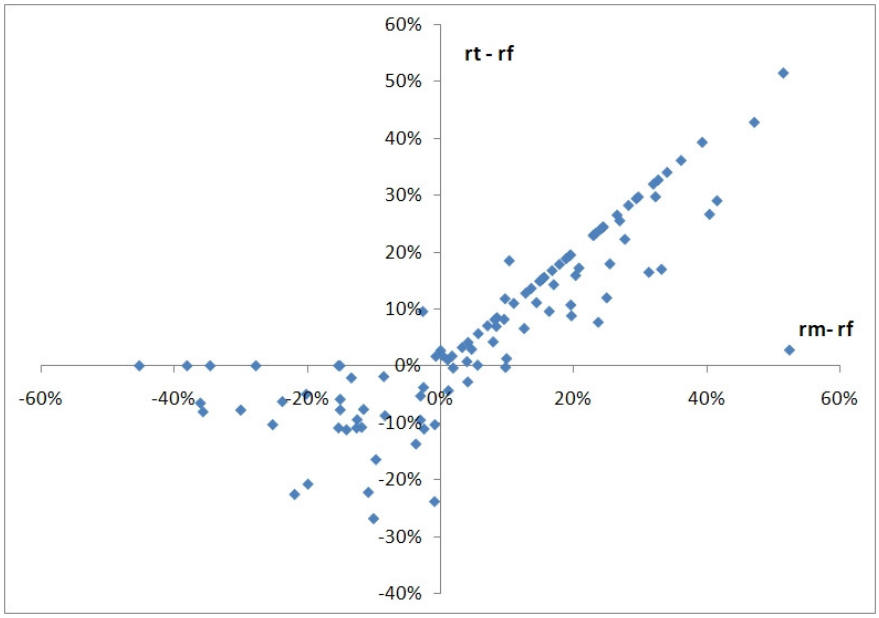
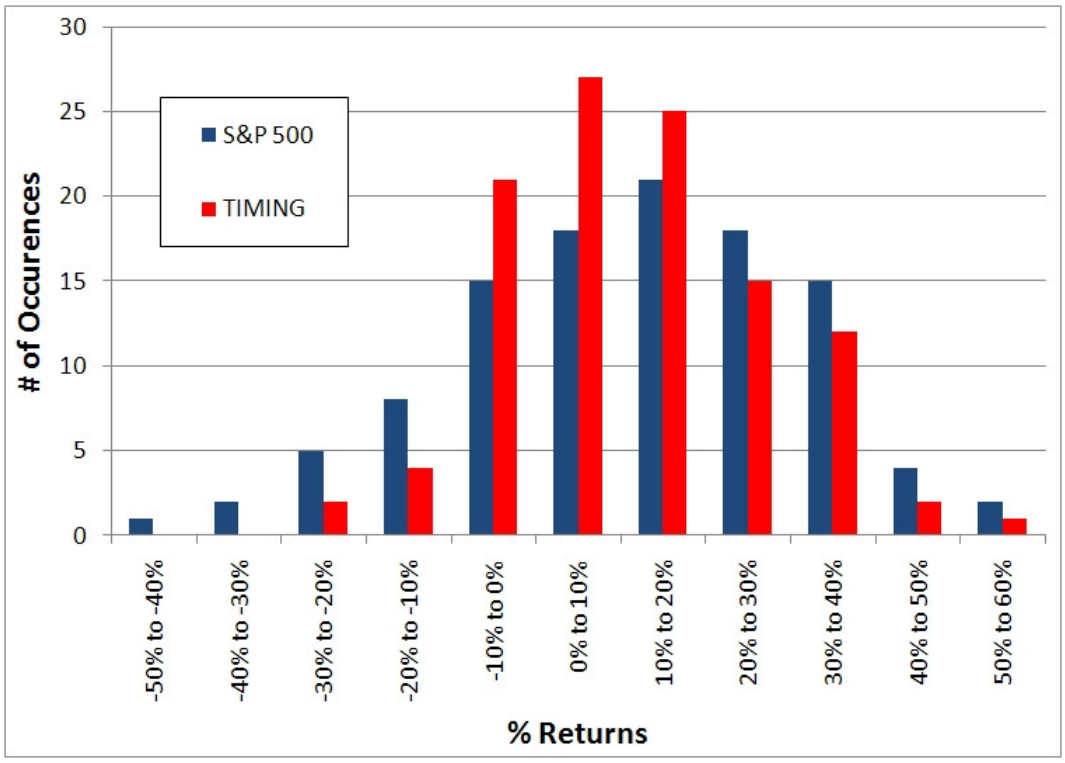


Exhibit 10 gives a good pictorial description of the results of the trend-following system applied to the S&P 500. The timing system has fewer occurrences of both large gains and large losses, with correspondingly higher occurrences of small gains and losses. Essentially, the system is a model that signals when an investor should be long a riskier asset class with potential upside, and when to be out and sitting in cash. It is this move to a lower-volatility asset class (T-bills) that drops the overall risk and drawdown of the portfolio.

Exhibit 10: Yearly Return Distribution, S&P 500 and Timing 1900-2008

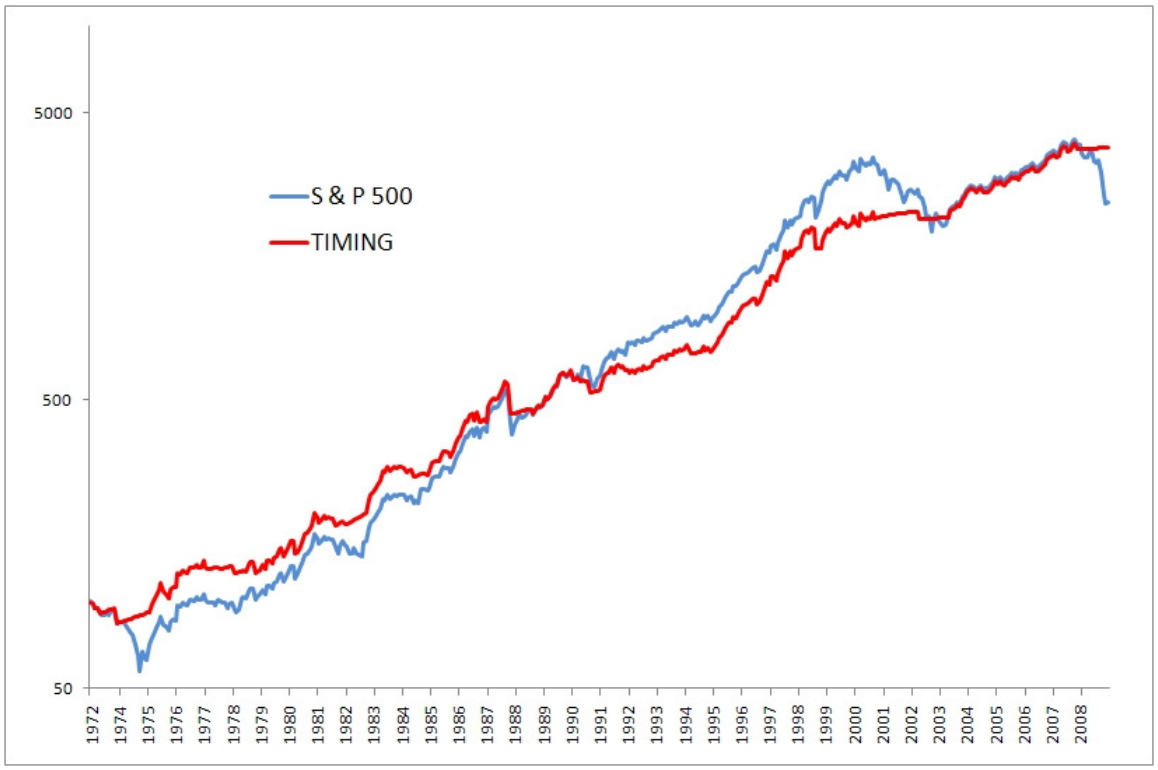


Appendix B breaks down the returns down by decade for the S&P 500 and the timing model. While the timing model outperforms in about half of all decades on an absolute basis, it improves risk-adjusted returns in about two-thirds of all decades and improves drawdown in all but one decade. Another interesting observation is the wide variance in Sharpe ratios per decade for buy and hold, ranging from -.43 (or -.04 if you exclude this unfinished decade) to 1.44. This decade has seen compound returns of -4% per year for buy and hold while the 1950s saw returns of 19% per year. A good rule of thumb is that risky asset classes have Sharpe ratios that cluster around 0.20, while a diversified portfolio is around 0.40.

OUT-OF-SAMPLE TESTING

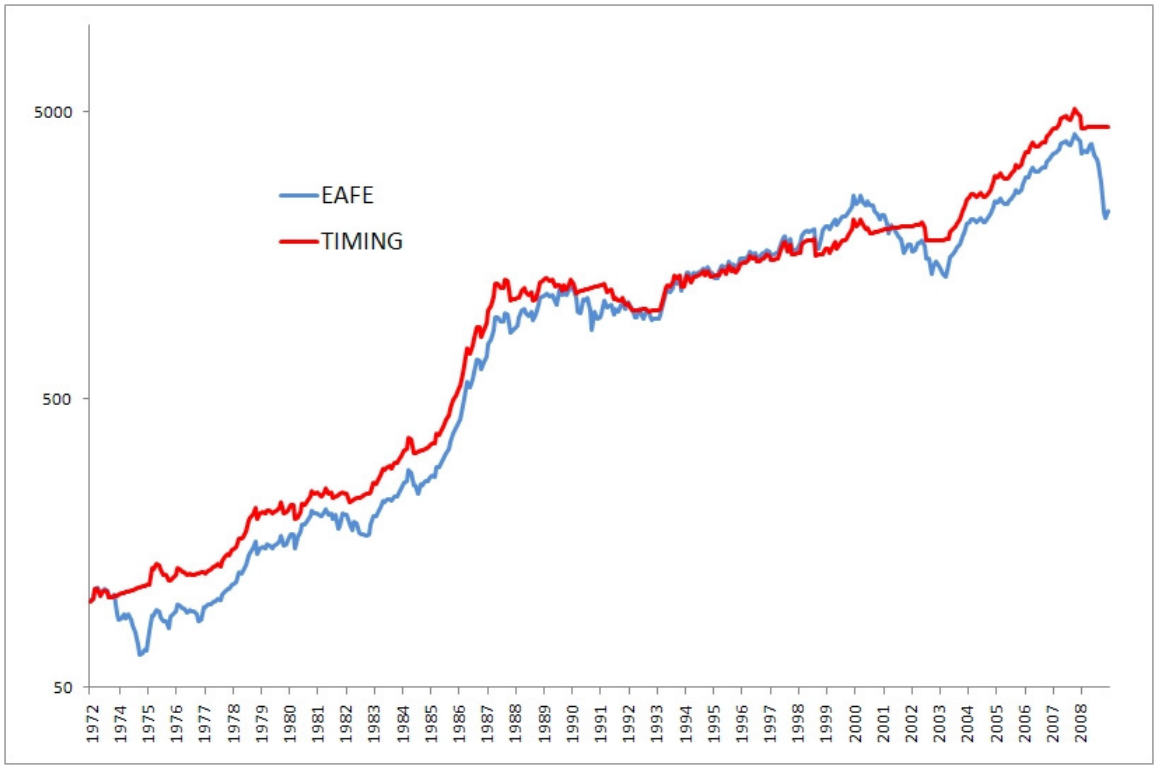
Here we examine the results of a simple trend-following asset allocation model that follows the same timing system presented earlier. In addition to the S&P 500, four diverse asset classes were chosen, including foreign stocks (MSCI EAFE), U.S. bonds (10-year Treasuries), commodities (GSCI), and real estate (NAREIT). Exhibits 11 through 15 present the results for each asset class and the respective timing results.

Exhibit 11: S&P 500 and Timing 1973-2008



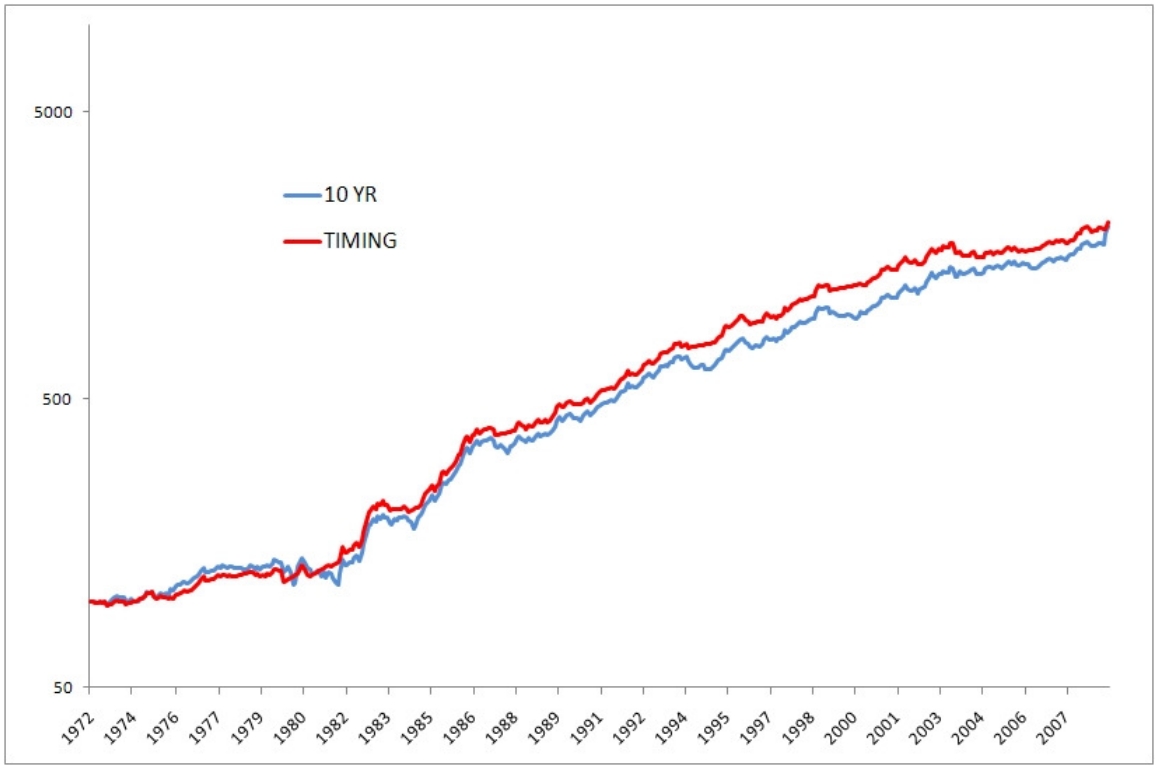
	S&P500	Timing	% Change
Annualized Return	9.26%	10.60%	14.52%
Volatility	15.55%	11.90%	(23.42%)
Sharpe (6%)	0.21	0.39	84.44%
Maximum drawdown	(44.73%)	(23.26%)	(48.01%)
% Time Long	-	72.92%	-
Round Trip Trades Per Year	-	0.67	-
% + Trades	-	58.33%	-
Average Winning Trade	-	32.32%	-
Avg Win Trade Length	-	21.00	-
Average Losing Trade	-	(4.98%)	-
Avg Losing Trade Length	-	1.90	-

Exhibit 12: MSCI EAFE and Timing 1973-2008



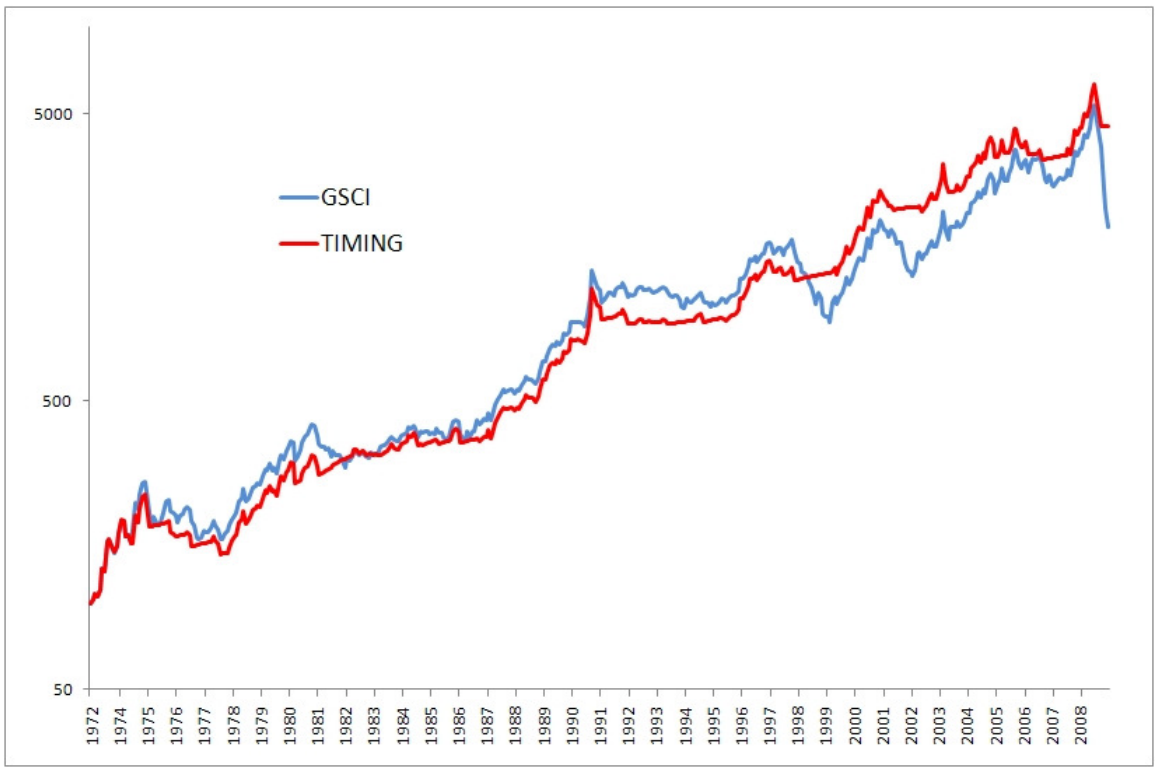
	EAFE	Timing	% Change
Annualized Return	9.04%	11.10%	22.83%
Volatility	17.18%	12.47%	(27.40%)
Sharpe (6%)	0.18	0.41	131.22%
Maximum drawdown	(49.21%)	(23.16%)	(52.95%)
% Time Long	-	69.91%	-
Round Trip Trades Per Year	-	0.75	-
% + Trades	-	44.44%	-
Average Winning Trade	-	45.80%	-
Avg Win Trade Length	-	20.08	-
Average Losing Trade	-	(5.17%)	-
Avg Losing Trade Length	-	3.93	-

Exhibit 13: 10 Year US Government Bonds and Timing 1973-2008



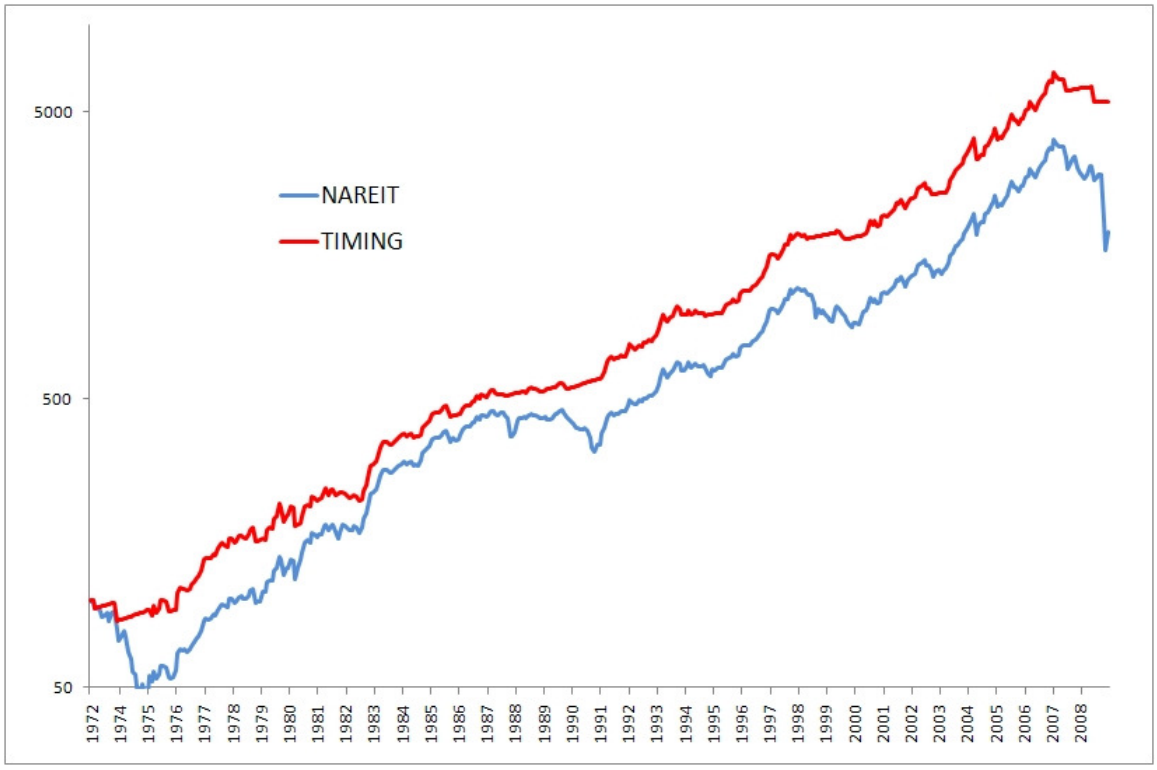
	10 Year	Timing	% Change
Annualized Return	8.69%	8.79%	1.18%
Volatility	9.06%	7.48%	(17.46%)
Sharpe (6%)	0.30	0.37	25.78%
Maximum drawdown	(18.79%)	(11.20%)	(40.40%)
% Time Long	-	76.16%	-
Round Trip Trades Per Year	-	0.69	-
% + Trades	-	48.00%	-
Average Winning Trade	-	27.81%	-
Avg Win Trade Length	-	23.33	-
Average Losing Trade	-	(1.62%)	-
Avg Losing Trade Length	-	3.62	-

Exhibit 14: GSCI and Timing 1973-2008



	GSCI	Timing	% Change
Annualized Return	8.73%	11.16%	27.94%
Volatility	20.48%	17.04%	(16.78%)
Sharpe (6%)	0.13	0.30	127.65%
Maximum drawdown	(62.16%)	(37.83%)	(39.15%)
% Time Long	-	66.90%	-
Round Trip Trades Per Year	-	0.83	-
% + Trades	-	36.67%	-
Average Winning Trade	-	33.06%	-
Avg Win Trade Length	-	16.26	-
Average Losing Trade	-	(3.19%)	-
Avg Losing Trade Length	-	3.47	-

Exhibit 15: NAREIT and Timing 1973-2008



	NAREIT	Timing	% Change
Annualized Return	8.54%	11.74%	37.42%
Volatility	17.06%	11.55%	(32.29%)
Sharpe (6%)	0.15	0.50	233.28%
Maximum drawdown	(58.78%)	(20.90%)	(64.44%)
% Time Long	-	72.45%	-
Round Trip Trades Per Year	-	0.61	-
% + Trades	-	54.55%	-
Average Winning Trade	-	41.26%	-
Avg Win Trade Length	-	23.00	-
Average Losing Trade	-	(5.13%)	-
Avg Losing Trade Length	-	3.60	-

It is nice to see that the results were consistent across asset classes. Absolute returns, risk-adjusted returns and maximum drawdowns were all improved by using the timing model. Exhibit 16 below shows that, on average, the timing model increased returns by approximately 20%, decreased volatility by 20%, improved the Sharpe Ratio by 0.20, and

reduced the maximum drawdown by nearly 50%. Put differently, in the five asset classes tested, the timing approach improves the results over buy-and-hold in each of the four metrics (return, volatility, Sharpe and drawdown) for each of the five asset classes.

The timing model keeps the investor invested roughly 70% of the time. Approximately half of the trades are winners, and winning trades are nine times bigger than losing trades. Time spent in winning trades is roughly 20 months, compared to only three months for losing trades.

Exhibit 16: Average Statistics across the Five Asset Classes, 1973-2008

	AVERAGE % Change
Annualized Return	20.86%
Volatility	(23.47%)
Sharpe (6%)	120.96%
Maximum drawdown	(48.99%)
	AVERAGE STATS
% Time Long	71.67%
Round Trip Trades Per Year	0.71
% + Trades	48.40%
Average Winning Trade	36.05%
Avg Win Trade Length	20.73
Average Losing Trade	(4.02%)
Avg Losing Trade Length	3.30

Given the ability of this very simplistic market timing rule to add value to various asset classes, it is instructive to examine how the returns would look in the context of an investor's portfolio. The returns for a buy and hold allocation are referenced as "Buy & Hold" or "B&H" and are equally weighted across the five asset classes. The timing model also uses equal weightings and treats each asset class independently – it is either long the asset class or in cash with its 20% allocation of the funds. Exhibit 17 illustrates the percentage of months in which various numbers of asset classes were held. It is evident that the system keeps the investor 60%-100% invested the vast majority of the time.

Exhibit 17: Percent of the Time Invested, 1973-2008

# of Positions	% Invested	# of Months	% of Months
0 (all cash)	0%	5	1.16%
1	20	20	4.63%
2	40	52	12.04%
3	60	94	21.76%
4	80	164	37.96%
5	100	97	22.45%
Total		432	100.00%

Exhibits 18 and 18b below present the results for the buying and holding of the five asset classes equal-weighted (B&H) versus the timing portfolio. The buy and hold returns are quite respectable on a stand-alone basis and present evidence of the benefits of diversification. However, the additional advantages conferred by timing are striking. Timing results in a reduction of volatility to single-digit levels, as well as a single-digit

maximum drawdown. Drawdown is reduced from 35% to less than 10%, and the investor would not have experienced a down year since inception in 1973. Exhibit 19 details the yearly returns, and post-2005 is highlighted as the out-of-sample period. The monthly returns are included in Appendix C.

Exhibit 18: Buy & Hold vs. Timing Model, 1973-2008, log scale

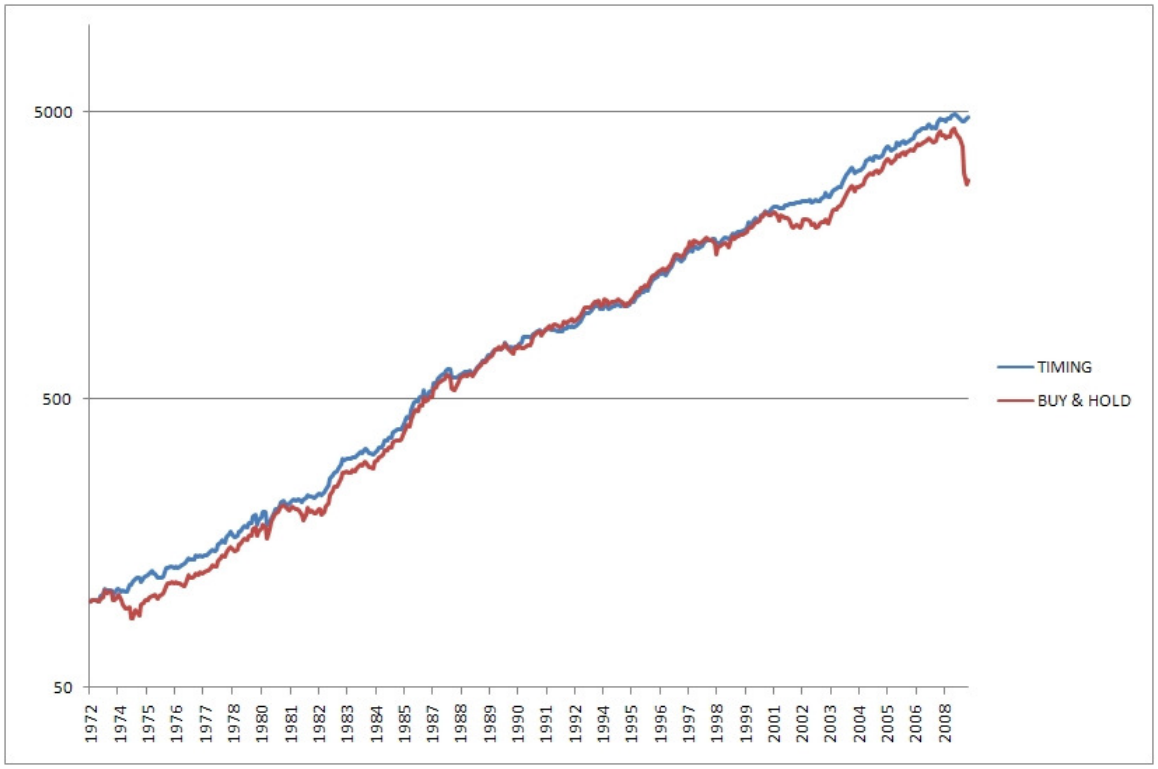


Exhibit 18b: Buy & Hold vs. Timing Model, 1973-2008, non-log scale

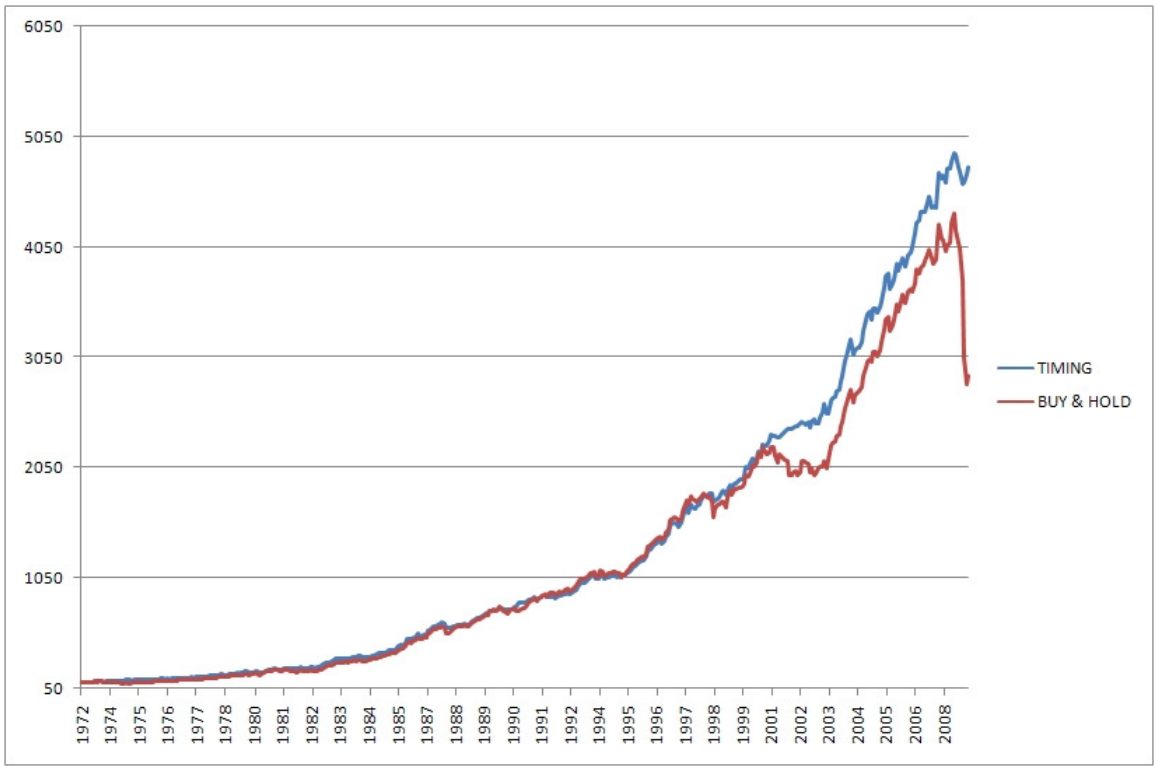


Exhibit 19: Yearly Returns for Buy & Hold vs. Timing Model, 1973-2008

	B&H	TIMING
1973	1.03%	7.39%
1974	(11.80%)	12.07%
1975	20.16%	1.46%
1976	15.04%	16.01%
1977	8.24%	7.20%
1978	13.65%	11.88%
1979	17.89%	14.65%
1980	18.95%	12.91%
1981	(3.34%)	4.80%
1982	21.34%	22.06%
1983	17.97%	15.77%
1984	9.43%	6.98%
1985	26.58%	26.20%
1986	25.50%	21.54%
1987	8.53%	11.63%
1988	18.46%	11.74%
1989	19.25%	18.12%
1990	(1.10%)	4.94%
1991	18.19%	6.34%
1992	3.88%	4.72%
1993	11.90%	12.82%
1994	1.76%	2.43%
1995	22.75%	21.74%
1996	19.31%	19.25%
1997	9.96%	9.94%
1998	(0.49%)	7.38%
1999	14.16%	13.05%
2000	12.73%	13.78%
2001	(9.74%)	3.21%
2002	2.09%	3.39%
2003	25.70%	20.53%
2004	17.44%	15.06%
2005	11.74%	8.20%
2006	12.07%	14.16%
2007	7.87%	9.49%
2008	(30.09%)	(0.59%)
	B&H	TIMING
Return	9.77%	11.27%
Volatility	9.73%	6.87%
Sharpe (6%)	0.39	0.77
Maximum Drawdown	(35.98%)	(9.53%)
Best Year	26.58%	26.20%
Worst Year	(30.09%)	(0.59%)

An obvious extension of this approach is to apply leverage to the timing portfolio to generate excess returns. An investor would simply invest twice as much in each asset class – instead of the 20% allocation to each asset class the allocation would now be 40%. The maximum portfolio exposure would be 200% if all five asset classes were on buy signals simultaneously. Exhibits 20 and 21 detail results for the 2X-levered portfolio.

The first noticeable observation is that the 2X model does not produce 2X returns, and this is due to the fact the investor must borrow funds to finance the leverage at current margin rates (otherwise known as the broker call rate). The 2X-levered portfolio produces very similar risk statistics as buy and hold, but adds approximately 500 basis points to the return.

Implementing the leveraged model at many retail brokerages is not ideal due to prohibitive borrowing costs.[9] Leveraged ETFs likewise are not ideal due to large tracking error relative to the benchmark index. An investor must be careful when pursuing leveraged returns.

[9] Interactive Brokers consistently has reasonable margin rates although we do not use them.

Exhibit 20: Buy & Hold vs. Timing and Leveraged Timing Model, 1973-2008

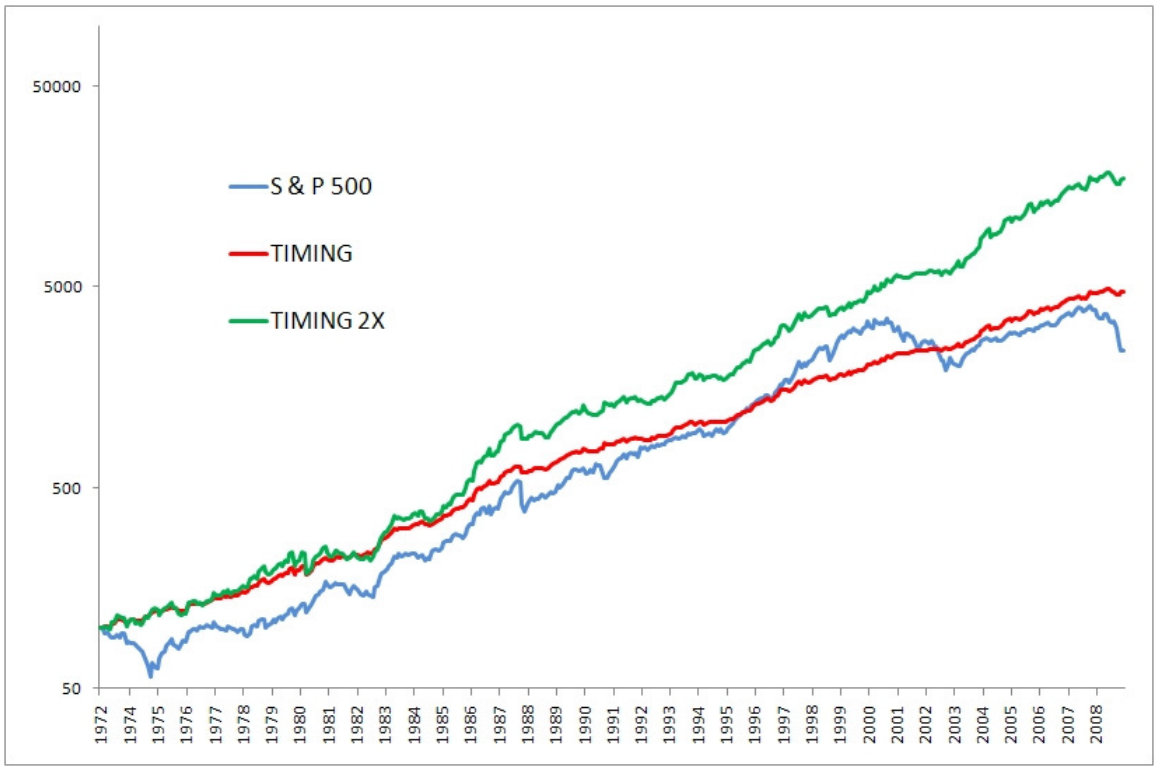


Exhibit 21: Summary Annualized Returns for Leveraged Timing Model, 1973-2008

	TIMING 2X
Return	15.27%
Volatility	13.78%
Sharpe (6%)	0.67
Maximum Drawdown	(21.91%)
Best Year	46.12%
Worst Year	(5.40%)

It is possible that Siegel (or others) have optimized the moving average by looking back over the period tested. As a check against optimization, and to show that using the 10-month SMA is not a unique solution, Exhibit 22 presents the stability of using various moving averages lengths ranging from 6 to 12 months. Calculation periods will perform

differently in the future as cyclical and secular forces drive the return series, but all of the parameters below seem to work similarly for a long-term trend-following application.

Exhibit 22: Parameter Stability of Various Moving Average Lengths, Timing Model 1973-2008

	6	8	10	12
Annualized Return	10.70%	11.08%	11.27%	11.53%
Volatility	6.6%	6.7%	6.9%	7.0%
Sharpe	0.71	0.76	0.77	0.79
Maximum Drawdown	-9.50%	-9.50%	-9.50%	-9.50%

While it is instructive to examine the model in various asset classes, the true test of a model is how it performs out of sample in real time. Since the paper was originally published in 2006 with results up to 2005, returns after 2005 should be seen as out of sample. Exhibit 23 illustrates the returns for B&H and timing portfolios.

Exhibit 23: Summary Annualized Returns for B&H vs. Timing Model, 2006-2008

	B&H	Timing
Annualized Return	(5.46%)	7.51%
Volatility	14.95%	5.92%
Sharpe 3.5%	-0.60	0.68
Maximum drawdown	(35.98%)	(5.88%)

PRACTICAL CONSIDERATIONS AND TAXES

There are a few practical considerations an investor must analyze before implementing these models for real-world applicability – namely, management fees, taxes, commissions, and slippage.

Management fees should be identical for both the buy and hold and timing models, and will vary depending on the instrument used for investing. Ten to 100 basis points is a fair estimate for these fees using ETFs and no-load mutual funds.

Commissions should be a minimal factor due to the low turnover of the models. On average, the investor would be making three to four round-trip trades per year for the entire portfolio and less than one round-trip trade per asset class per year. Likewise, slippage should be nearly negligible, as there are numerous mutual funds (end-of-day pricing means zero slippage) as well as liquid ETFs an investor can choose from.

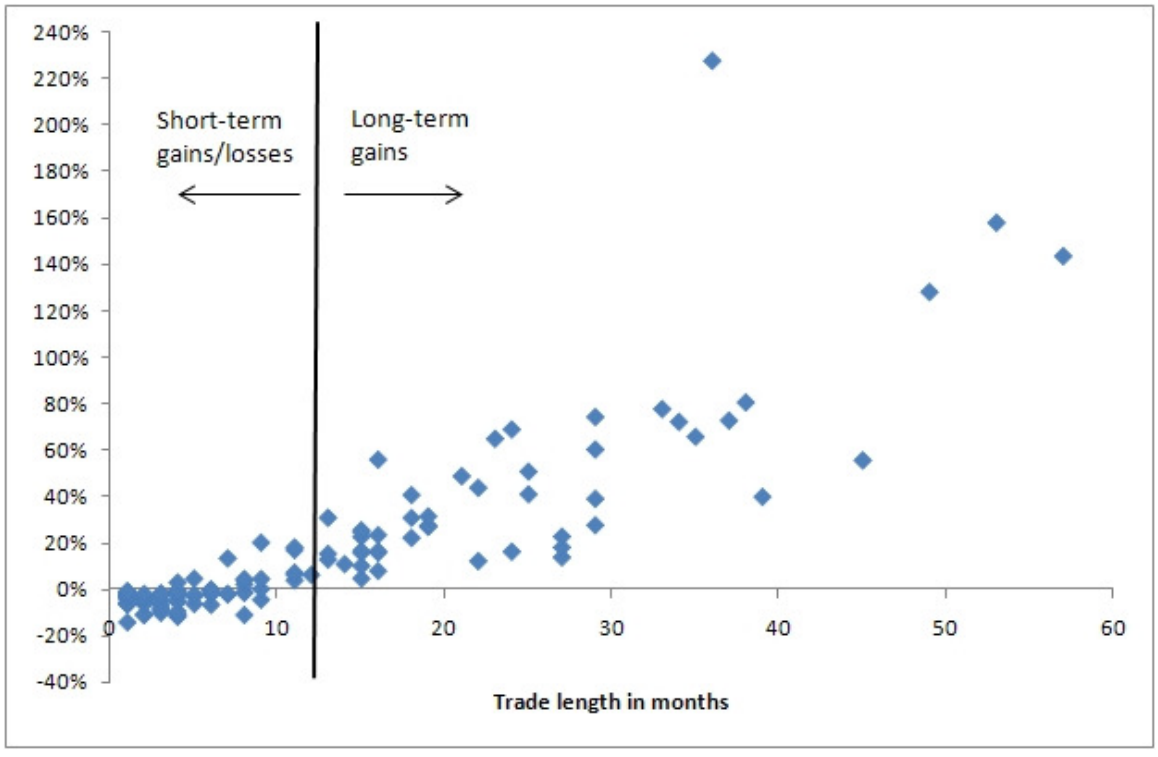
Taxes, on the other hand, are a very real consideration. Many institutional investors such as endowments and pension funds enjoy tax-exempt status. The obvious solution for individuals is to trade the system in a tax-deferred account such as an IRA or 401(k). Due to the various capital gains rates for different investors (as well as varying tax rates across time, as well as the impact of dividends) it is difficult to estimate the hit an investor would suffer from trading this system in a taxable account. Most investors rebalance their holdings periodically and introduce some turnover into the portfolio – and it is reasonable to assume a normal turnover of approximately 20%. The system has a turnover of almost 70%.

Gannon and Blum (2006) presented after-tax returns for individuals invested in the S&P 500 since 1961 in the highest tax bracket. After-tax returns to investors with 20% turnover would have fallen to 6.72% from a pre-tax return of 10.62%. They estimate that

an increase in turnover from 20%-70% would have resulted in an additional haircut of less than 50 basis points to 6.27%.

There is some good news for those who have to trade this model in a taxable account. The system results in a high number of short-term capital losses, and a large percentage of long-term capital gains. Exhibit 24 depicts the distribution for all the trades for the five asset classes since 1973. This should help reduce an investor's tax burden.

Exhibit 24: Length of Trades for Timing Model, 1973-2008



VOLATILITY CLUSTERING

One of the benefits of a quantitative system is that it protects the investor from innate behavioral biases. A discussion of some of the more insidious biases can be found in the Appendix. Of course, this information is not only valuable for figuring out our own biases - other people's mistakes leave the door open for us to soak up some of that elusive alpha. As far as excess returns are concerned, for someone to gain, someone else has to lose. People consistently make the same mistakes that are hard-wired into their brains, and they do so over and over again.

Humans use a different part of their brain when they are losing money than when they are making money. Exhibit 25 below shows the annualized returns and volatility for the five markets we studied in this paper. On average, the returns are 80% lower and the volatility 30% higher when the market is below its 10-month simple moving average. Commodities are the one exception where volatility is not higher when below the moving average, which makes intuitive sense. Commodities are often driven by supply shocks that can result in price spikes.

2008 is a prime example with volatility levels in stock markets around the globe exploding to record levels. However, this volatility has occurred *after* the markets already began declining.

Exhibit 25: Volatility Clustering Across Various Asset Classes

Asset Class	Market > 10 month SMA	Market < 10 month SMA	Difference
US Stocks			
% of time	72.92%	27.08%	
Annualized Return	13.53%	3.02%	-77.67%
Annualized Volatility	13.89%	19.22%	38.38%
Foreign Stocks			
% of time	69.91%	30.09%	
Annualized Return	14.64%	1.89%	-87.08%
Annualized Volatility	14.86%	21.51%	44.77%
Bonds			
% of time	76.10%	23.90%	
Annualized Return	10.08%	6.34%	-37.04%
Annualized Volatility	8.69%	10.17%	16.97%
Commodities			
% of time	66.90%	33.10%	
Annualized Return	16.21%	1.13%	-93.03%
Annualized Volatility	20.78%	19.65%	-5.43%
Real Estate			
% of time	72.45%	27.55%	
Annualized Return	14.89%	-1.44%	-109.69%
Annualized Volatility	13.51%	23.78%	75.95%
AVERAGE			
% of time	71.66%	28.34%	
Annualized Return	13.87%	2.19%	-84.22%
Annualized Volatility	14.35%	18.87%	31.49%
US Stocks 1901-2008			
% of time	69.88%	30.12%	
Annualized Return	14.42%	3.03%	-78.98%
Annualized Volatility	14.30%	24.18%	69.06%

CONCLUSION

My purpose in this paper was to create a simple-to-follow method for managing risk in a single asset class and, by extension, a portfolio of assets. A non-discretionary, trend-following model acts as a risk-reduction technique with no adverse impact on return. When tested on various markets, risk-adjusted returns were almost universally improved. Utilizing a monthly system since 1973, an investor would have been able to increase risk-adjusted returns by diversifying portfolio assets and employing a market-timing solution. In addition, the investor would have also been able to sidestep many of the protracted bear markets in various asset classes. Avoiding these massive losses would have resulted in equity-like returns with bond-like volatility and drawdown.

DATA SOURCES

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 & 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.

APPENDIX A - LITERATURE REVIEW MOMENTUM & TREND-FOLLOWING

The application of a trend-following methodology to financial markets is not a new endeavor, and an entire book by Michael Covel (2005) has been written on the subject. The rules and criteria of a trend-following strategy are incredibly varied and unique. Although we will touch briefly on some of the academic literature here, a more thorough treatment of the subject is presented by Tezel and McManus (2001), as well as by Carr (2008) and Ostgaard (2008).

There have been many attempts to describe the success of trend-following and momentum trading systems. Kahneman and Tversky (1979) provided a behavioral framework entitled prospect theory that describes how humans have an irrational tendency to be less willing to gamble with profits than with losses. In short, investors tend to sell their winners too early, and hold on to losers too long.

Two of the oldest and most discussed trend-following systems are the Dow Theory, developed by Charles Dow, and the Four Percent Model, developed by Ned Davis. *The Research Driven Investor* by Timothy Hayes (2001) and *Winning on Wall Street* by Martin Zweig (1986) present good reviews of each system, respectively.

Alfred Cowles and Herbert Jones found evidence of momentum as early as the 1930s (1937). H.M. Gartley (1945) mentions methods of relative strength stock selection in his *Financial Analysts Journal* article "Relative Velocity Statistics: Their Application in Portfolio Analysis." Robert Levy (1968) identified his own system in *The Relative Strength Concept of Common Stock Price Forecasting*. Other literature penned by investors who suggest using momentum in stock selection include James O'Shaughnessy's (1998) book, *What Works on Wall Street*, Martin Zweig's (1986) *Winning on Wall Street*, William O'Neil's (1988) *How to Make Money in Stocks*, and Nicolas Darvas's (1960) *How I Made $ 2,000,000 in the Stock Market*.

The group at Merriman Capital Management (MCM) has completed a number of quantitative backtests utilizing market timing on equities, bonds, and gold. The group uses their own strategies to manage client money. Tilley and Merriman (1998-2002) describe the characteristics of a market-timing system, as well as the emotional and behavioral difficulties in following such a system.

Wilcox and Crittenden (2005), in "Does Trend-Following Work on Stocks?", take up that question applied to the domestic equities market and conclude that trend-following can work well on stocks even when adjusting for corporate actions, survivorship bias, liquidity, and transaction costs.

An entirely different product area where trend-following is heavily utilized is the futures arena. Many global macro hedge funds and commodity-trading advisors (CTAs), such as John Henry and Bill Dunn, have been using trend-following systems on futures for years, amassing billions of dollars under management. While futures trend-following is quite a different strategy than what is detailed in this paper, Mulvey, Simsek, and Kaul (2003) break down the total return of a futures trend-following strategy into its component parts. The return consists of collateral yield (cash sitting in T-bills), trend-following gains, and rebalancing gains in order of return contribution. They assert that collateral yield is the largest chunk of return, a point often overlooked.

APPENDIX B – S&P 500 & Timing Returns By Decade

1900s	S&P 500	TIMING
Return	9.93%	13.81%
Volatility	12.65%	9.20%
Sharpe	0.41	0.98
Maximum Drawdown	(34.06%)	(9.18%)
T-bills	4.76%	4.76%
1910s	**S&P 500**	**TIMING**
Return	4.35%	7.51%
Volatility	11.91%	8.72%
Sharpe	-0.02	0.33
Maximum Drawdown	(27.90%)	(10.18%)
T-bills	4.64%	4.64%
1920s	**S&P 500**	**TIMING**
Return	14.78%	18.13%
Volatility	16.36%	13.94%
Sharpe	0.67	1.02
Maximum Drawdown	(33.44%)	(23.45%)
T-bills	3.88%	3.88%
1930s	**S&P 500**	**TIMING**
Return	(0.47%)	3.15%
Volatility	37.98%	16.97%
Sharpe	-0.03	0.15
Maximum Drawdown	(79.84%)	(30.63%)
T-bills	0.64%	0.64%
1940s	**S&P 500**	**TIMING**
Return	8.99%	5.52%
Volatility	16.11%	13.63%
Sharpe	0.53	0.37
Maximum Drawdown	(28.12%)	(34.74%)
T-bills	0.47%	0.47%
1950s	**S&P 500**	**TIMING**
Return	19.26%	17.40%
Volatility	11.92%	11.42%
Sharpe	1.44	1.34
Maximum Drawdown	(15.05%)	(14.99%)
T-bills	2.05%	2.05%

APPENDIX B Continued – S&P 500 & Timing Returns By Decade

1960s	S&P 500	TIMING
Return	7.76%	7.12%
Volatility	12.11%	8.89%
Sharpe	0.30	0.34
Maximum Drawdown	(22.25%)	(12.79%)
T-bills	4.07%	4.07%
1970s	**S&P 500**	**TIMING**
Return	5.88%	8.40%
Volatility	15.99%	10.85%
Sharpe	-0.04	0.18
Maximum Drawdown	(42.64%)	(15.88%)
T-bills	6.50%	6.50%
1980s	**S&P 500**	**TIMING**
Return	17.55%	15.27%
Volatility	16.39%	14.46%
Sharpe	0.51	0.42
Maximum Drawdown	(29.58%)	(23.26%)
T-bills	9.23%	9.23%
1990s	**S&P 500**	**TIMING**
Return	18.21%	13.09%
Volatility	13.43%	12.04%
Sharpe	0.98	0.67
Maximum Drawdown	(15.37%)	(16.47%)
T-bills	4.98%	4.98%
2000s	**S&P 500**	**TIMING**
Return	(3.56%)	6.30%
Volatility	15.25%	8.16%
Sharpe	-0.43	0.40
Maximum Drawdown	(44.73%)	(6.82%)
T-bills	3.04%	3.04%

APPENDIX C – Monthly Timing Model Returns 1973-2008

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1973	0.72%	0.49%	(0.25%)	(0.42%)	4.13%	0.52%	4.60%	(0.09%)	(0.44%)	(0.40%)	(3.70%)	2.28%	**7.39%**
1974	2.59%	0.35%	(2.36%)	0.77%	(0.79%)	0.68%	5.28%	(0.40%)	2.98%	2.28%	1.11%	(0.82%)	**12.07%**
1975	(2.87%)	3.31%	1.53%	0.69%	1.66%	1.79%	(2.17%)	(0.45%)	(3.06%)	0.00%	0.70%	0.52%	**1.46%**
1976	6.56%	0.72%	0.53%	0.09%	(1.08%)	1.44%	(1.35%)	1.15%	1.64%	0.36%	1.67%	3.45%	**16.01%**
1977	(1.35%)	0.12%	0.46%	2.52%	(0.69%)	1.45%	(1.84%)	1.62%	0.41%	0.31%	2.35%	1.72%	**7.20%**
1978	(0.98%)	0.99%	4.51%	0.61%	1.88%	(1.17%)	4.10%	2.52%	1.84%	(2.90%)	(0.90%)	1.06%	**11.88%**
1979	2.77%	0.23%	3.13%	1.37%	(1.25%)	3.35%	0.05%	5.79%	1.15%	(7.32%)	3.78%	1.31%	**14.65%**
1980	4.99%	(0.29%)	(9.27%)	1.17%	3.15%	4.59%	3.12%	0.80%	1.84%	3.66%	1.48%	(2.18%)	**12.91%**
1981	(1.76%)	0.71%	3.17%	0.91%	(1.16%)	0.83%	(0.16%)	(1.42%)	1.25%	1.16%	2.99%	(1.65%)	**4.80%**
1982	0.14%	(0.85%)	0.88%	1.99%	0.69%	(1.61%)	2.25%	3.05%	2.44%	6.37%	2.10%	2.88%	**22.06%**
1983	0.76%	2.24%	3.02%	4.63%	(0.70%)	1.29%	(0.97%)	0.34%	1.11%	(0.19%)	1.35%	1.99%	**15.77%**
1984	1.66%	(1.02%)	2.73%	0.02%	(2.95%)	(0.09%)	(0.67%)	1.07%	1.70%	2.14%	0.74%	1.58%	**6.98%**
1985	3.98%	(0.18%)	2.13%	(0.19%)	4.46%	1.63%	1.05%	0.08%	0.18%	4.45%	3.42%	2.67%	**26.20%**
1986	(1.04%)	6.13%	5.76%	1.45%	(0.65%)	3.68%	0.44%	5.08%	(3.43%)	(0.01%)	2.54%	0.20%	**21.54%**
1987	6.59%	0.91%	3.54%	1.55%	1.01%	1.28%	1.99%	1.56%	(0.39%)	(6.68%)	0.38%	(0.17%)	**11.63%**
1988	1.80%	0.34%	1.94%	0.90%	(0.36%)	0.24%	0.66%	(2.27%)	1.05%	3.56%	1.32%	2.10%	**11.74%**
1989	2.37%	0.33%	1.76%	2.56%	0.36%	1.76%	2.39%	(0.28%)	1.86%	(1.53%)	2.11%	3.18%	**18.12%**
1990	(2.61%)	(1.17%)	0.49%	(0.32%)	0.37%	0.20%	2.08%	1.20%	5.16%	(0.46%)	(0.26%)	0.34%	**4.94%**
1991	(0.59%)	2.76%	1.00%	1.00%	1.72%	(2.93%)	1.70%	1.08%	0.94%	1.13%	(2.28%)	0.79%	**6.34%**
1992	(0.48%)	(0.67%)	(0.82%)	0.78%	1.87%	(0.19%)	2.01%	(0.25%)	1.03%	(0.90%)	1.07%	1.22%	**4.72%**
1993	2.11%	1.96%	4.08%	0.39%	0.10%	1.03%	1.06%	3.04%	0.53%	0.88%	(3.32%)	0.44%	**12.82%**
1994	2.77%	(0.41%)	(2.42%)	1.36%	0.73%	0.47%	0.63%	0.14%	(1.37%)	1.37%	(1.42%)	0.67%	**2.43%**
1995	0.90%	1.76%	0.81%	1.80%	2.56%	0.36%	2.50%	0.37%	1.96%	(0.46%)	2.68%	4.70%	**21.74%**
1996	1.18%	0.54%	1.69%	1.74%	0.62%	1.33%	(2.15%)	2.01%	2.80%	1.58%	5.47%	1.08%	**19.25%**
1997	0.44%	(1.06%)	(1.25%)	1.72%	3.49%	2.23%	3.44%	(2.93%)	4.76%	(1.64%)	(0.55%)	1.17%	**9.94%**
1998	0.72%	2.44%	2.08%	(0.12%)	0.01%	1.41%	0.16%	(4.42%)	1.34%	0.05%	1.37%	2.31%	**7.38%**
1999	0.99%	(1.79%)	1.86%	2.56%	(2.07%)	2.98%	0.03%	1.03%	0.87%	(0.03%)	2.09%	3.99%	**13.05%**
2000	(0.65%)	1.60%	2.71%	(1.95%)	1.57%	3.04%	(0.90%)	4.20%	(0.59%)	(0.47%)	2.82%	1.80%	**13.78%**
2001	(0.61%)	0.12%	(0.39%)	0.18%	0.03%	1.45%	0.45%	1.26%	(0.21%)	0.11%	0.53%	0.26%	**3.21%**
2002	0.24%	0.82%	0.62%	(0.55%)	(0.18%)	0.92%	(2.21%)	1.91%	1.03%	(1.26%)	(0.31%)	2.41%	**3.39%**
2003	1.70%	3.00%	(2.99%)	(0.18%)	4.33%	1.11%	0.69%	1.80%	0.24%	2.76%	2.00%	4.62%	**20.53%**
2004	1.60%	3.00%	1.61%	(4.18%)	1.32%	0.51%	0.27%	1.56%	3.20%	2.86%	1.76%	0.80%	**15.06%**
2005	(2.19%)	2.74%	0.16%	(1.20%)	1.64%	1.45%	3.33%	2.98%	0.62%	(3.80%)	1.41%	1.02%	**8.20%**
2006	3.88%	(1.64%)	2.07%	0.77%	(1.96%)	1.34%	1.41%	0.73%	1.26%	2.90%	2.26%	0.45%	**14.16%**
2007	1.98%	(0.24%)	0.27%	2.00%	1.10%	(2.40%)	0.36%	(0.33%)	3.93%	3.34%	(1.30%)	0.58%	**9.49%**
2008	(1.15%)	2.62%	0.01%	1.24%	1.66%	(0.17%)	(2.30%)	(1.02%)	(2.41%)	(0.10%)	0.01%	1.15%	**(0.59%)**

APPENDIX D – BEHAVIORAL BIASES

Humans display all sorts of behavioral biases that muck up our chances for investment success. Remember piling into the dot-coms in the late 1990s only to sell them in 2003? You're not alone; investors love to herd into an asset class at the top and sell at the bottom. Stock funds accounted for 99% and 123% of mutual fund flows in 1999 and 2000. People were selling off their other holdings to plow money into stocks. Reported mutual fund returns are almost always higher than individual investor returns due to this poor timing.

From 1973 through 2002 Nasdaq stocks gained 9.6% per year, but because most investors pumped in money from 1998 through 2000, the typical dollar invested earned only 4.3% a year (Dichev 2007). Tale after tale of irrationality in financial markets can be found in Charles Mackay's *Extraordinary Popular Delusions and the Madness of Crowds* and Charles Kindleberger's *Manias, Panics, and Crashes*".

The field known as behavioral finance was founded in the 1970s to study these phenomena as applied to financial markets. Much of the early work was done by professors Amos Tversky and Daniel Kahneman. While there are dozens of documented ways in which people are irrational when it comes to money, here are some of the more insidious biases:

Overconfidence - 82% of drivers say they are in the top 30% of drivers, and 80% of students think they will finish in the top half of their class (Tilson 2005).

Information overload - More information often decreases the accuracy of predictions, all the while increasing confidence in those predictions. Paul Andreassen, a psychologist formerly at Harvard University, conducted a series of laboratory experiments in the 1980s to see how investors respond to news. He found that because of excessive trading people who pay close attention to news updates actually earn lower returns than people who seldom follow the news.

Herding - From 1987 through 2007, the S&P returned over 10% per year. However, the average investor in a stock mutual fund earned only 4.48%. That means that over these past 20 years, the average equity mutual fund investor would have barely kept up with inflation (Dalbar 2008).

Avoiding losses - People feel the pain of loss twice as much as they derive pleasure from an equal gain (Tversky 1979). Over forty years ago in *Common Stocks and Uncommon Profits* Philip Fisher wrote, "There is a complicating factor that makes the handling of investment mistakes more difficult. This is the ego in each of us. None of us likes to admit to himself that he has been wrong… More money has probably been lost by investors holding a stock they really did not want until they could "at least come out even" than from any other single reason."

Anchoring - During normal decision making, individuals anchor (or overly rely on) specific information or a specific value and then adjust to that value. Once the anchor is set, there is a bias toward that value. Warren Buffet laments: "When I bought something at X and it went up to X and 1/8th, I sometimes stopped buying, perhaps hoping it would come back down. We've missed billions when I've gotten anchored. I cost us about $10 billion (by not buying enough Wal-Mart). I set out to buy 100 million shares, pre-split, at $23. We bought a little and it moved up a bit and I thought it might come back a bit –who knows? That thumb-sucking, the reluctance to pay a little more, cost us a lot" (2004 Berkshire Hathaway annual meeting*).*

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