MR Swing:
A quantitative system for mean-reversion and swing trading in market regimes

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1. Abstract

MR Swing is a quantitative system that employs daily mean-reversion and swing trading in different market regimes to produce enhanced absolute and risk adjusted returns (e.g. in one configuration 23% CAGR, 54% risk adjusted CAGR, 1.37 Sharpe, 13% max drawdown). The system uses four key design principles: market-regime-switching, non symmetrical trading algorithms, volatility adaptive metrics, and robustness to regime whipsaws. An extensive analysis of out-of-sample ETFs and managed futures demonstrates the robust performance of the system over ten years. Finally, MR Swing is incorporated as a component in a diversified portfolio of ETFs (modeled after university endowments) and is shown to significantly increase the portfolio's return while reducing the maximum drawdown.

This paper describes a quantitative method for trading equity indexes (ETFs and futures) that can increase return and reduce volatility when used in a diversified portfolio. The system is designed to be adaptive to changes in market volatility over the short-term, and also deploys techniques aligned to the dominant market regime. After recapping the robust performance metrics across various ETFs and futures, we demonstrate how MR Swing improves the performance and risk profile as a component in a portfolio with asset class allocations inspired by large university endowments: The Ivy Portfolio (Faber and Richardson 2009).

The MR Swing system is based on four core principles: (1) *Market-regime-switching*, (2) *Non symmetrical trading algorithms*, (3) *Volatility adaptive metrics*, and (4) *Robustness to regime whipsaws.* The first principle is *market-regime-switching*. Markets behave differently in different environments. We quantify the current market environment or regime, and then adopt a trading approach best suited to it. An example of regime switching (Kestner 2003) uses a trend-following method (the 40-day/20-day channel breakout) in trending markets, and counter-trend trading (14-day relative strength index (RSI)) in non-trending markets. The average directional index (ADX) is used to define the market regime as trending or non-trending.

Table 1: Example of Regime Switching (Kestner 2003)

ADX < 20	trend to begin soon	40-day/20-day channel breakout
20<ADX<30	mean-reversion in prices	14-day RSI strategy
ADX>30	trending prices	40-day/20-day channel breakout

In MR Swing we simply quantify two regimes: bull and bear. One could have more complex regimes based on price volatility, option implied volatility, and other factors. We use a short-term mean-reversion method in the bear regime, and swing trading technique in the bull regime.

The second principle is *non symmetrical trading algorithms*. Most trading strategies simply reverse the rules for bull and bear. For example, in Tactical Equity Allocation Model (T.E.A.M.) the system (Lent

2009) buys short-term mean-reversion on a daily time-fame, when the weekly percent trend channel has had an upside breakout. The system reverses these rules to short a rally in the daily timeframe after a weekly channel breakdown. Most counter-trend systems pick one overbought/oversold oscillator and then symmetrically buy oversold and short overbought. These common techniques assume that markets behave in a symmetrical manner in different market regimes. We show that entirely unique techniques are more responsive to regime conditions rather than using symmetrical techniques. The swing trading component uses different algorithms for entries and exits. In addition, we employ different methods based on the regime to make a non symmetrical algorithm.

Our third principle of *volatility adaptive metrics* requires that each individual component of the system must be capable of robustly handling changes in market volatility. For example, when we quantify the dominant market regime using a trend-following method, we employ a channel based on price to reduce whipsaws and get the benefits of hysteresis. Next, every metric we use for mean-reversion and swing trading entries/exits was carefully chosen to include volatility in the algorithm. In the mean-reversion component, the overbought/oversold levels are calculated using an adaptive technique that normalizes the data using nonparametric statistics (i.e. we do not assume that prices exhibit a Gaussian distribution).

The final principle is *robustness to regime whipsaws*. Regardless of the method we use to define the current market regime, false alarms or whipsaws will occur. Classic moving average trend-following systems are very prone to losses in a sideways market. Instead of trying to eliminate whipsaws in the regime model, we instead structure each component to be able to withstand whipsaws. That means, an entry in the swing trading regime must be able to handle a change to the mean-reversion regime without causing the system to become unstable. MR Swing is designed to address these cases and ensure robustness to changes in regime, including whipsaws.

2. Mean-Reversion in Equity Indexes

The major equity market indices exhibited daily follow-through last century, but have been very much in a mean reverting environment since about 2000. Stokes showed (Stokes 06/09/2009 and 08/10/2009) how daily follow-through worked well 1950 to 2000, but then it reversed. We suggest that this change to mean-reversion is due to the increased speed at which news and data is priced into the market. In particular, computerized trading, discount brokers with low-cost commissions, and the world-wide-web started to reach critical mass around 2000. These factors may have structurally changed how the indices behave and are reflected in our system design.

In the study below, we compare daily follow-through to daily mean-reversion in the S&P 500 equity index. The rules for follow-through are simple: if today's close is higher than yesterdays, then go long. If it is lower than yesterday then reverse and go short. Daily mean-reversion is the opposite.

Algorithm 1: Daily Follow-Through Rules
if ($C > C_1$) *then buy*
if ($C < C_1$) *then sell short*

Algorithm 2: Daily Mean-Reversion (MR) Rules
if ($C > C_1$) *then sell short*
if ($C < C_1$) *then buy*

The results of these two systems over the last ten years are shown below.

Table 2: Comparing Daily Follow-Through to Daily Mean-Reversion
$100,000 portfolio from 10/01/2000 to 02/01/2010

System	CAGR	Sharpe	Portfolio Value	Max Wins	Max Losers	Profit Factor	Percent Profitable	Max DD
Daily Follow-Through	-16.20%	-1.01	$19,097	7	9	0.82	33.67%	87.30%
Daily Mean-Reversion	15.42%	0.78	$383,899	9	7	1.25	66.17%	26.13%

As you can see, daily mean-reversion has been a respectable system over the last ten years with 15.42% compound annual growth rate (CAGR) and 66% of trades profitable with a reasonable drawdown of 26%. The chart below compares the growth of a $100,000 portfolio trading the two systems between 2000 and 2010.

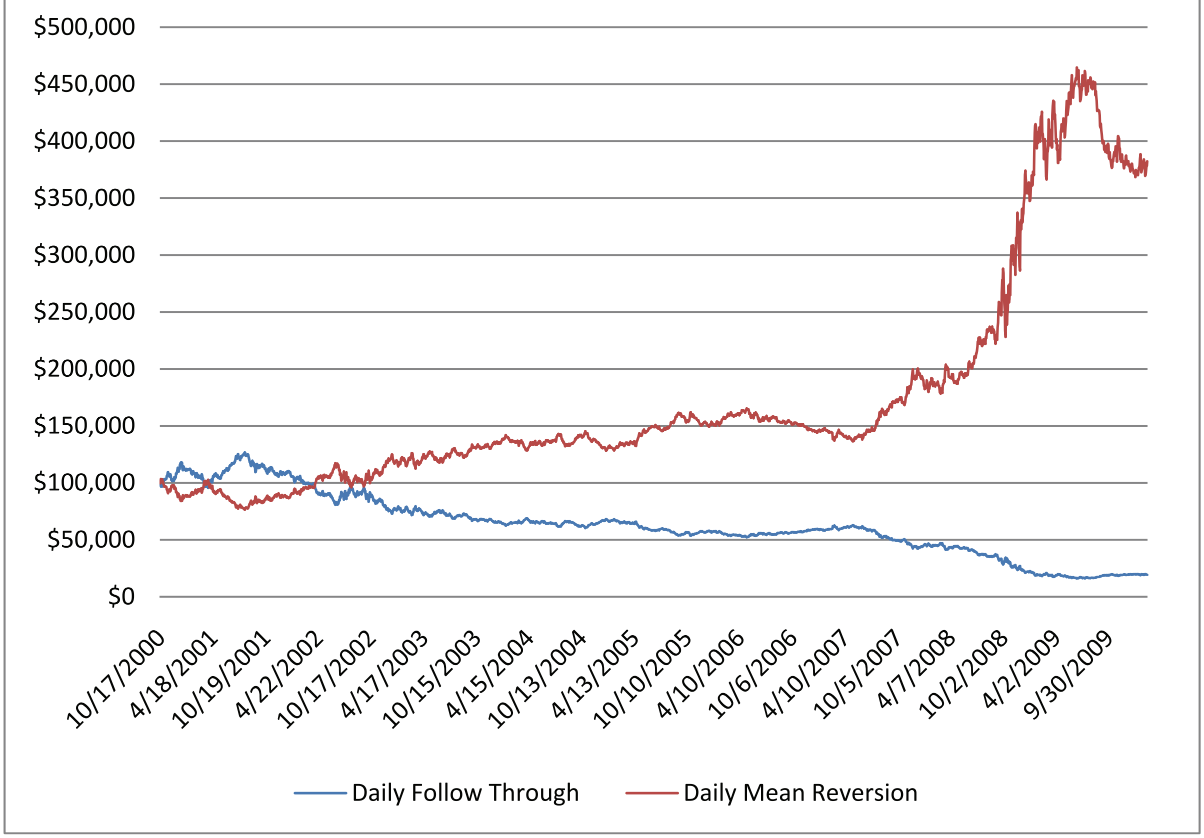


Figure 1: Daily Mean Reversion vs. Daily Follow Through

We will delve deeper into mean-reversion and identify ways to improve on the base system. The benchmark for our system is the daily mean-reversion system because of its simplicity and performance metrics. The system that we design must improve on the simple daily mean-reversion shown above in order to justify the added complexity.

2.1. Mean-Reversion in Market Regimes

We define market regimes based on a 200-day simple moving average. We choose a 200-day moving average based on research done by (Siegel 1998) that showed over the last century a 200-day moving average filter would have reduced volatility in a long-term stock portfolio.

$$\mu_C = \frac{\sum_{i=0}^{N-1} C_i}{N} \quad \textit{where } N = 200 \qquad \tau = IFF((C > \mu_C), 1, -1) \qquad \text{(Algorithm 3)}$$

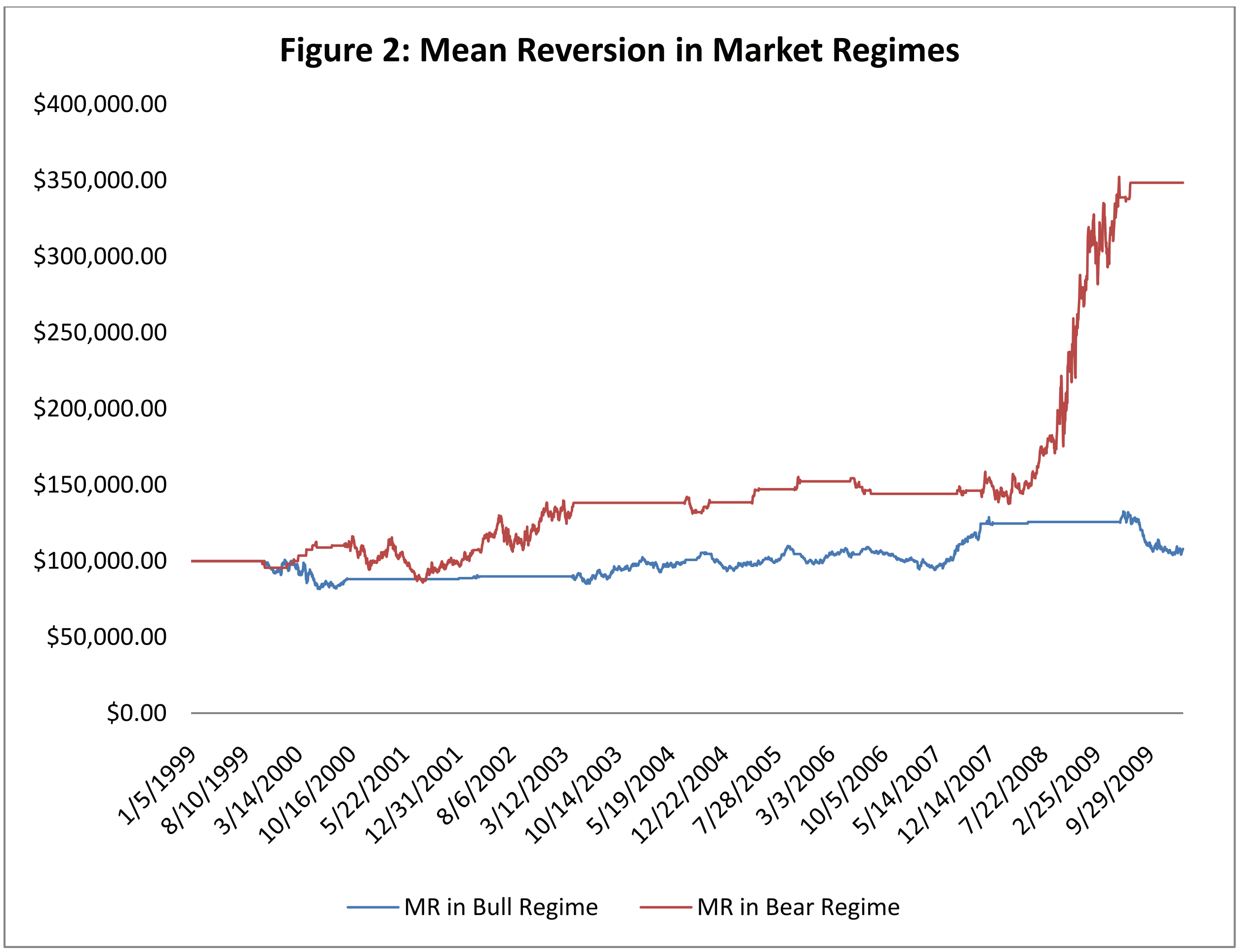
$$\tau = 1 \;\; \textit{bull regime} \qquad \tau = -1 \;\; \textit{bear regime}$$

Below shows the results of mean-reversion in bull and bear market regimes.

Table 3: Daily Mean-Reversion (MR) in Market Regimes
$100,000 portfolio from 01/05/1999 and 02/12/2010

System	CAGR	CAGR risk adj	Sharpe	Portfolio Value	Time in Market	Max Wins	Max Losers	Profit Factor	Percent Profitable	Max DD
MR in Bull	0.69%	1.30%	-0.09	$108,346	53%	11	7	1.03	65.36%	21.62%
MR in Bear	11.89%	28.80%	0.72	$348,498	43%	12	5	1.40	66.02%	26.14%

Daily mean-reversion is a more dominant force during a bear market (11.89% CAGR, 0.72 Sharpe) compared to bull markets. Mean-reversion thrives on the heightened volatility of bear markets.



The MR Swing system will be designed to take advantage of the outperformance of mean-reversion in the bear regime, and we will use a different strategy in bull regimes.

3. Quantitative Trading System

While we used data analysis in the previous sections to understand market structure for our system, it is important to avoid curve fitting when designing a quantitative trading system (Bryant 2006). In particular, we start with these guidelines:

- *Default parameter settings*: all indicators and system components should use default values, instead of optimizing them for the highest net profit.
- *Avoid optimization*: optimization will only be used to test if a system component adds value, not to choose specific settings.
- *Long Timeframe*: we choose the last ten years as our timeframe. This gives us enough data for a robust analysis, and also keeps us trading the current market, and not last century's market.
- *Many Trades*: trend-following system that only trade a few times per year may have drastically different results if you miss a small sample of trades. We prefer a system that generates many trades (e.g. MR Swing generates ~400 trades in the current analysis) because this adds to our confidence that system results are not overly influenced by a small set of trades.
- *Out-of-Sample Testing*: we originally designed the system for the SPY, and will show the out-of-sample results on the QQQQ, EEM, EWM, VTI as well as the futures @ES and @NQ.

Our system design starts with the core principles outlined in the introduction: (1) we exploit different characteristics of markets by using a *market-regime-switching* method to take advantage of short-term mean-reversion in the bear regime, and deploy swing trading in the bull regime. Next, we will employ (2) *non symmetrical trading algorithms* for entries, exits and the regime specific trading algorithms. Every system component must be based on (3) *volatility adaptive metrics* so that it can handle changes in volatility over a long time span. Finally, we recognize that no regime switching model will be able to eliminate all false signals and each core system component must exhibit (4) r*obustness to regime whipsaws.*

3.1. Quantifying Market Regimes

There are many ways to define the market regime. A complete study of different market regimes is beyond the scope of this paper. MR Swing identifies market regimes based on a 200-day moving average channel of the highs and lows. When the system is in the bull regime, it only allows the channel to increase, and vice versa in bear. The reason we choose a channel over just a moving average is to get the benefits of hysteresis (Alves 2009) and reduce whipsaws by using a range of values before switching from bull to bear regime.

Hysteresis (Hysteresis 2010) is a natural phenomenon that appears in magnetism, elastics, cell mitosis and control theory (e.g. thermostats). These systems exhibit path dependence in which the current state depends on the path taken to achieve it. The system has memory and the effects of the current input are only felt after a delay or range threshold is exceeded. We believe that markets also need time to respond to new information and that response does take into consideration recent market history. Our market regime filter requires price to close below the low of the channel before switching into a bear regime.

Algorithm 4: Moving Average Trend Channel

$$\mu_L = \frac{\sum_{i=0}^{N-1} L_i}{N} \qquad \mu_H = \frac{\sum_{i=0}^{N-1} H_i}{N}$$

$$\rho = IFF(\tau = 1, \mathrm{MAX}(\mu_L, \rho), MIN(\mu_H, \rho))$$

$$\tau = IFF(C > \rho, 1, -1)$$

default N= 200

Simple moving average channel of the bar highs and lows. A bar close below the trailing channel ρ switches it to a down trend (τ = -1). In an uptrend (τ = 1) we only allow ρ to increase, such that in sideways market or retracement ρ does not change.

The market regime model shown below in Figure 3 is from 2005 to 2010 on a daily chart of the SPY.

Figure 3: Market Regime Trend Channel on SPY from 2005 to 2010

200-day SMA channel of bar highs and lows (increment only in direction of the trend).

This technique captures the major market trends with fewer whipsaws than using the traditional 200-day SMA. Instead of attempting to design a long term market regime filter that removes all whipsaws, we require each component to exhibit (4) r*obustness to regime whipsaws* in the core trading algorithm.

A key design in the algorithm is not to exit a position just because the dominant market regime changed. Instead, we hold on to the position, and simply change the entry/exit rules based on the new regime. The mean-reversion and the swing components must be able to handle this behavior without a serious drawdown. This is one reason the system structure is designed for major equity market indexes as opposed to individual (especially illiquid) equities, which may have a price shock due to a stock specific news announcement. MR Swing's patience in waiting for a high probability exit to the trade after a regime change has been extensively tested and shown to greatly improve in the equity curve.

3.2. Bear Regime: Short-term Mean-Reversion (MR)

We can improve on the daily mean-reversion system in section 2 by employing an adaptive short-term mean-reversion algorithm. Some quantitative systems have used a two period relative strength index RSI(2) for daily mean-reversion. Although this would work fine in MR Swing, we choose the DVO (David Varadi Oscillator, 2009) because it meets our principle of a (3) *volatility adaptive metric*. The Percent-Rank function is used to normalize the daily data, and this nonparametric technique robustly adapts to market volatility changes.

Algorithm 5: Generalized DVO and DV2

$$\theta(\bar{\boldsymbol{w}}, \bar{\boldsymbol{s}}, N) = \sum_{i=0}^{N-1} [\frac{C_i}{(H_i w_0 + L_i w_1 + O_i w_2 + C_i w_3)}] * s_i$$

$$where \sum_{i=0}^{N-1} s_i = 1 \quad and \sum_{j=0}^{3} w_j = 1$$

$$\boldsymbol{DVO}(\bar{\boldsymbol{w}}, \bar{\boldsymbol{s}}, N, M) = PercentRank(\theta(\bar{\boldsymbol{w}}, \bar{\boldsymbol{s}}, N), M)$$

$$default\ N = 5\ and\ M = 252$$

$$\boldsymbol{DV2} = \boldsymbol{DVO}([0.5\ 0.5\ 0\ 0], [0.5\ 0.5\ 0\ 0\ 0], 5, 252)$$

The David Varadi Oscillator (DVO) was designed (Varadi 07/29/2009) to be a short-term oscillator using bar highs and lows (maximum smoothing period N=5). The DV2 is one specific setting originally designed for the SPY (the weighting period was 50/50 over the last two days). The DVO can be used to create unique weighting schemes that function best for each class of security and define a local weight density ($\bar{\boldsymbol{w}}\ \bar{\boldsymbol{s}}$) for the ETF or futures contract. It captures different cycle lengths, amplitudes, and return distributions of the security.

The DVO gives us the flexibility to customize the system to the different cycle lengths, amplitudes and return distribution of the particular security. Although we use the default values of the DV2 shown above, MR Swing's performance could be improved using this readily available feature of the DVO. The chart below shows the DVO in the mean-reversion component of MR Swing between 02/2008 and 08/2008. The system buys the next day open when DVO is less than 40% and shorts the next day open when DVO is above 70%. The magenta line above shows the market trend channel.

Figure 4: Mean-Reversion (MR) Trades in Bear Regime
Using DVO on SPY from 02/2008 to 08/2008

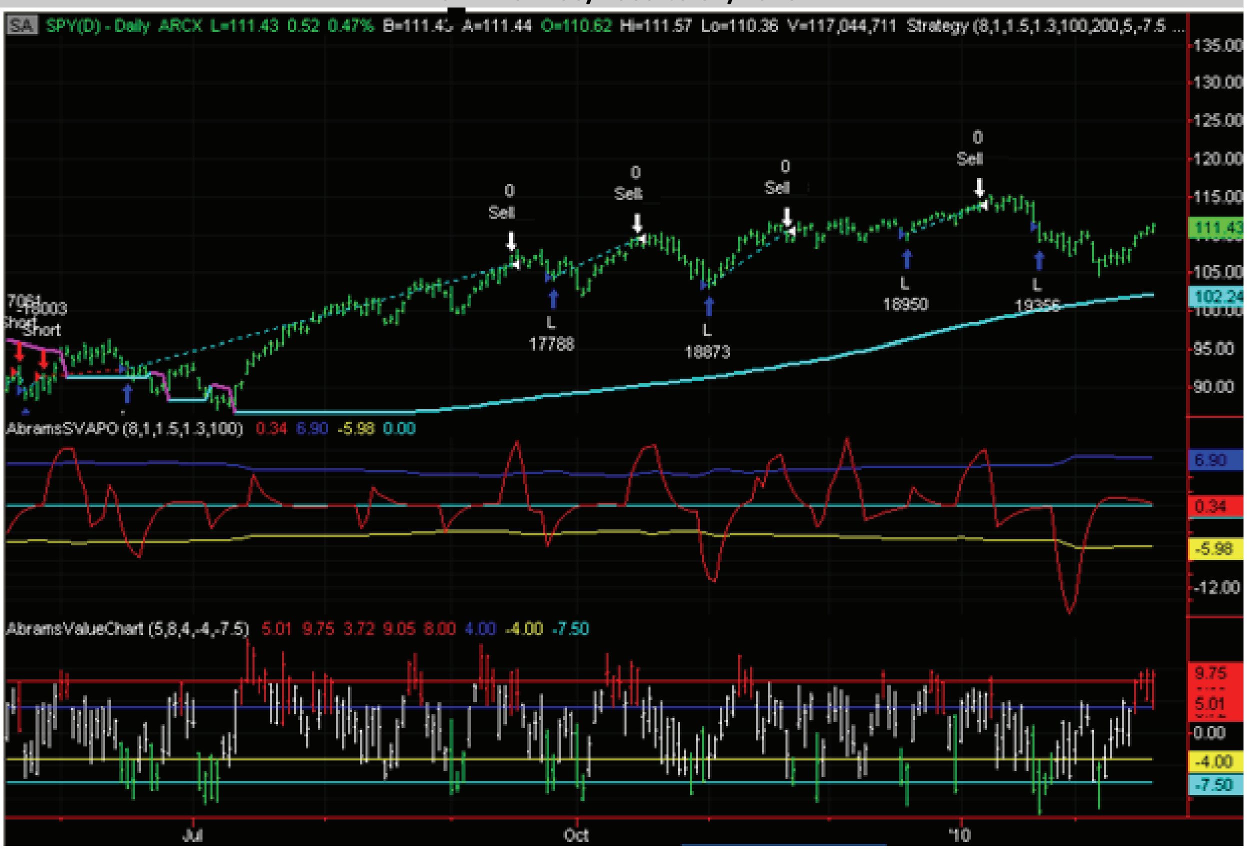
MR Swing actual trades on the SPY in 2008 during the bear regime to do mean-reversion using the DVO with default settings of the DV-2.

3.3. Bull Regime: Swing Trading

There are many methods for swing trading in bull markets. One systematic way of discretionary swing trading using multiple timeframes is the Triple Screen system (Elder 1993). First, the long-term trend is determined by requiring that the security must show positive momentum on the weekly timeframe (moving average convergence divergence (MACD) histogram for this week is higher than last week). Next, the market short-term trend on a daily chart is used to identify a pull-back using an oscillator (e.g. Elder's Force Index). The third and final screen is to put in a trailing buy stop at the highs of the bars until filled. The initial stop loss is at the low of the previous bar.

We take our inspiration for MR Swing's quantitative algorithm from the Triple Screen system. First, the dominant market regime must be a bull swing trading environment (Section 3.1). Second, we look for a pull-back entry (Section 3.3.1). Third, we patiently use a limit order entry technique (Section 3.3.2). Exits employ an intermediate term exhaustion indicator (Section 3.3.3).

Figure 5: Swing Trades in Bull Regime
SPY from 06/2009 to 02/2010



Value Chart oversold is used for entries. SVAPO overbought signals exhaustion points for the exits. Notice the regime changed from bear to bull in June 2009, switching from short-term MR to swing trading. Also the system handled the false alarm whipsaws in June/July.

3.3.1. Swing Entry in Bull Regime

We have found through experience that bull markets tend to have quick, sharp pullbacks and then slow grinding moves higher. This observation leads us to choosing a *non symmetrical trading algorithm* for swing trading. Entries use a *volatility adaptive metric* that is suited to finding fast pull-backs, and exits use an intermediate-term exhaustion method that includes price and volume. We choose the Value

Chart (Helweg and Stendahl, 2002) for entries because it dynamically identifies overbought and oversold levels even when price volatility changes over time. First a relative price chart is created, similar to a de-trended price oscillator. Then, it is adjusted by a dynamic volatility unit.

Algorithm 6: Value Chart

$$\gamma(i) = IFF\left(\left(|C_i - C_{i-1}| > H_i - L_i\right), \quad |C_i - C_{i-1}|, H_i - L_i \right)$$

$$\nabla = \frac{\sum_{i=0}^{N-1} \gamma(i)}{N} * \alpha \qquad \textit{dynamic volatility unit}$$

$$\mu = \frac{\sum_{j=0}^{N-1} {(H_j + L_j)}/{2}}{N} \qquad \textit{floating axis of relative price value}$$

$$V_O = \frac{O - \mu}{\nabla} \quad V_L = \frac{L - \mu}{\nabla}$$

$$V_H = \frac{H - \mu}{\nabla} \quad V_C = \frac{C - \mu}{\nabla}$$

$$where\ \alpha = 0.16, N = 5$$

Relative price chart that adapts to changes in market volatility. The value chart of the close is the distance between the close and the floating axis of relative price value (mean of the median price) divided by the dynamic volatility unit (mean of the bar range).

We use the default N=5 bar period for the Value Chart. An oversold level (-7.5) is based on the lows of the bars, so we are only using V_L in the algorithm to signal a potential pull-back entry point.

3.3.2. Limit Order Entry Technique

MR Swing uses extreme patience in entries and exits. Limit orders are used in swing trading to attempt to get an entry close to the low of a recent bar.

Algorithm 7: Limit Order Entries

$$\varepsilon_{Entry} = IFF((L_1 < L_2), L_1, L_2)$$

Each bar the limit order target price is recalculated to dynamically adapt to recent price changes and search for an entry. MR Swing patiently waits for the target price of the lowest low of the last two bars.

Sometimes an entry is missed because of this technique, but MR Swing is looking for low-risk entries at the expense of potentially missing a trade.

3.3.3. Swing Exit in Bull Regime

As a quantitative system, MR Swing needs a precise definition of market exhaustion when swing trading the bull regime. We choose a volume and price oscillator (Vervoort 2007) that measures exhaustion by combining the short-term price trend with the slope of the volume over time.

Algorithm 8: Volume and Price Oscillator (SVAPO)

```
SVAPO(Period=8, Cutoff=1, StDevH=1.5, StDevL=1.3, StDevPeriod=100)

//Vervoort's Heiken-Ashi is smoothed short-term price trend
AP = AVGPRICE;  // (O+H+L+C)/4
haO =0.5*(AP[1]+haO[1]);
haCl =0.25*(AP+haO+MAXLIST(AP,MAXLIST(High,haO)) + MINLIST(AP,Minlist(Low,haO)));
haC = TEMA(haCl,0.625*Period); //triple exponential moving ave of Heiken-Ashi close

//volume delta at each price (handle volume extremes)
VolumeValue = IFF(BarType<2, Ticks, Volume);
VAvg = AVERAGE(VolumeValue[1],5*Period);
VMax = 2*VAvg;
Vc = IFF(VolumeValue<VMax,VolumeValue,VMax);

//basic volume trend is triple exponential moving average of linear reg slope of volume
VTrend = TEMA(LINEARREGSLOPE(VolumeValue, Period),Period);

//Day Trend=UP if smoothed Heiken-Ashi and volume trend higher than previous bar
Up = haC>haC[1] * (1 +(0.001*Cutoff)) and COUNTIF(VTrend >= VTrend[1],2)=2;
Dn = haC<haC[1] * (1 -(0.001*Cutoff)) and COUNTIF(VTrend <= VTrend[1],2)=2;

//SVAPO is triple exponential moving average of the summation of volume
//each day's volume contribution depends on trend for that day
//UP days add the volume, DOWN days you subtract volume for that day from the sum
DELTA_SUM= SUMMATION(IFF(Up,Vc,IFF(Dn,-Vc,0)),Period)/(VAvg+1)
SVAPO = TEMA(DELTA_SUM,Period);

//dynamic bands using standard deviation of SVAPO over time
UpperBand = StDevH*STDDEV(SVAPO, StDevPeriod);
LowerBand = -StDevL*STDDEV(SVAPO, StDevPeriod);
```

Tradestation Easy Language code is shown for Volume and Price Oscillator (SVAPO) adopted from (Vervoort 2007). Upper and lower bands are generated around the oscillator based on standard deviations from the SVAPO mean, in order to make the indicator dynamic to changes in market volatility. When SVAPO closes above the upper band it signals an overbought market.

Using the default settings, the SVAPO tends to find excellent exhaustion points in the bull regime by combining short-term price trend and the slope of the volume trend. Note that we do not wait for confirmation of an exhaustion point like the traditional SVAPO system, instead we start looking for an exit using our limit order technique (Section 3.3.4) when SVAPO crosses above the top band.

3.3.4. Limit Order Exit Technique

Similar to entries MR Swing uses extreme patience looking for a high probability exit. Limit orders are used in swing trading to actively search for an exit close to the high of a recent bar.

Algorithm 9: Limit Order Exits

$$\varepsilon_{Exit} = IFF((H_1 > H_2), H_1, H_2)$$

Each bar the limit order target price is recalculated to dynamically adapt to recent price changes and search for an exit. MR Swing patiently waits for the target price of the highest high of the last two bars.

MR Swing keeps searching for a limit order exit on each bar. We also tested applying a trailing stop set at the simple moving average of the lows of the last 2 bars. This combined with the limit order exit, provides a balanced approach to exits that most times hit the limit order, and uses the trailing stop to protect profits.

4. Composite Strategy and Performance Results

Next we will combine each component of the algorithm into an end-to-end automated trading strategy. The components will be tested in three different variations, shown below:

Table 4: Strategy	Rules
MR Swing (counter) Aggressive	Take all counter-trend trades in all regimes. Always in the market (long or short) unless stopped out for that trade. Bear Regime: go long and short MR rules Bull Regime: go long and short swing trade rules
MR Swing (swing long, MR counter)	Take all counter-trend trades in bear regime using MR. Swing trade long only in bull regime, do not short a bull market. Bear Regime: go long and short MR rules Bull Regime: swing trade lone only (never short)
MR Swing (no counter) Conservative	Conservative system that only trades in the direction of the dominant market regime. Never counter-trend trade. Bear Regime: sell short using MR rules (never long) Bull Regime: go long swing trades (never short)

We compare an aggressive system that takes all counter-trend trades in both bull and bear regimes. A counter-trend trade in the swing trading system is simply to sell short instead of exiting when the limit order price is filled (Section 3.3.4). The next table shows the performance of MR Swing on the SPY, an ETF that follows the Standard and Poor's 500 Index of large capitalization US stocks.

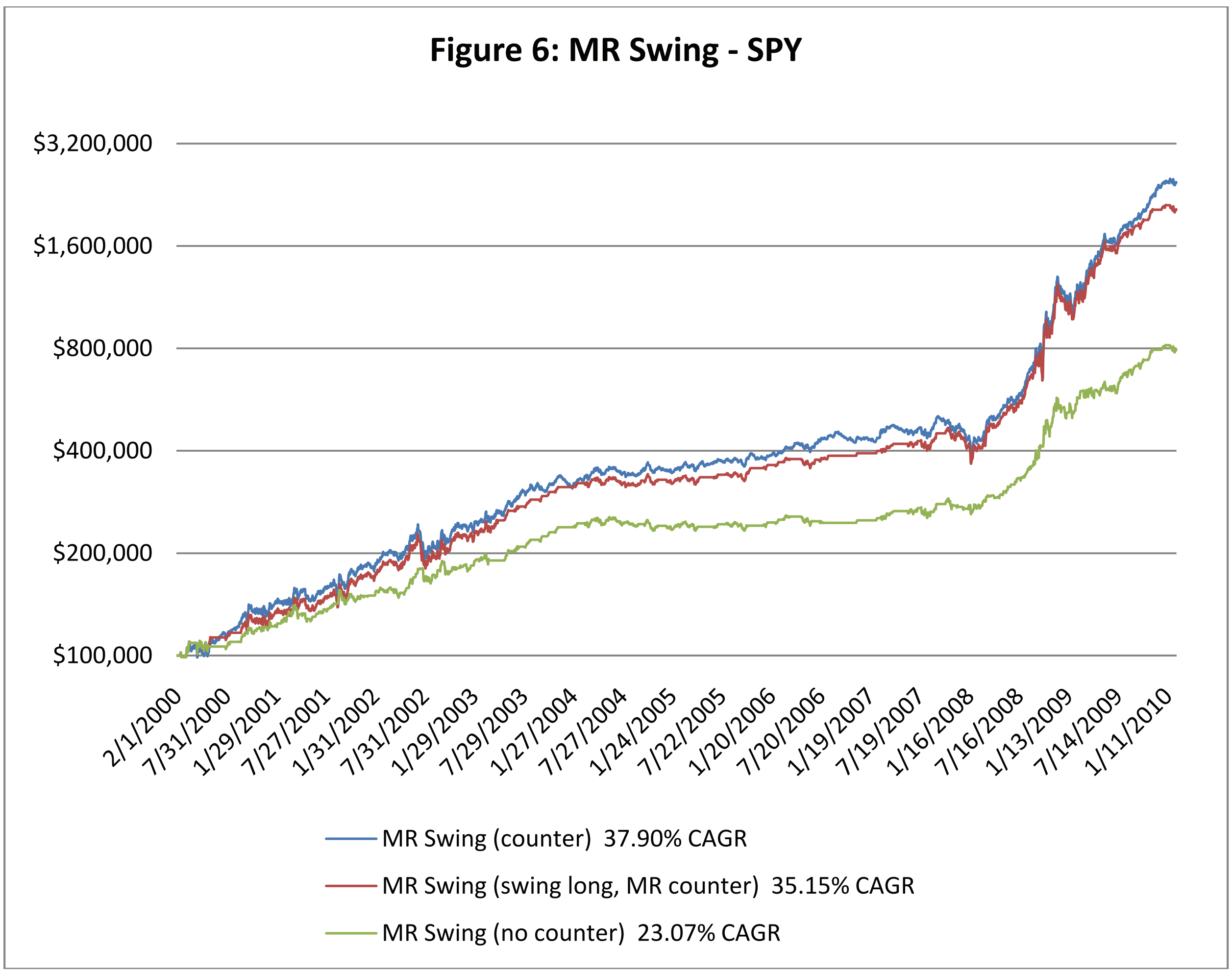
Table 5: MR Swing on SPY
$100,000 portfolio from 02/01/2000 to 02/12/2010

System	CAGR	CAGR risk adj	Sharpe	Portfolio Value	Time in Market	Max Wins	Max Losers	Profit Factor	Percent Profitable	Max DD
MR Swing (counter)	37.90%	38.34%	1.58	$2,484,277	98.81%	17	6	2.81	69.47%	23.65%
MR Swing (swing long, MR counter)	35.16%	51.25%	1.54	$2,068,616	72.79%	17	6	2.75	69.43%	21.68%
MR Swing (no counter)	23.07%	54.06%	1.37	$801,735	48.01%	15	3	3.25	74.23%	13.09%

The full counter-trend system is in the market 98.8% of the time (using a 20% per trade stop loss causes it to be out of the market 1.2% of the time). It shows a solid 37.9% compound annual growth rate (CAGR) and Sharpe of 1.58 with a max daily equity drawdown of 23.65%. Note that the drawdown figures are marked-to-market every trading day, so that you can see the true drawdown (as opposed to monthly figures or a trade-by-trade figure). The system reinvests the entire portfolio on every trade. Commissions and taxes are excluded. Slippage is excluded, but was tested as insignificant due to entries and exits with limit orders.

The conservative version of MR Swing takes no counter-trend trades. It is only in the market 48% of the time, and it still delivers 23% CAGR and the max drawdown is greatly reduced to 13%. Taking trades only with the trend also reduces the number of consecutive losing trades to just three over the last ten years. This is a key pragmatic issue for any manager or trader following an automated system, since there is a well known tendency for investors to withdraw funds and traders to turn off the system if the number of consecutive losses leads to a lack confidence in the system, often just before the system recovers (How many consecutive losing trades will you suffer before turning off the system?). We believe that this is one of the key strengths to employing MR Swing in live trading.

The next chart shows the performance of MR Swing, marked-to-market daily, over the last ten years. The conservative system shows much lower drawdown, but between 2004 and 2006 performance was flat. The system compounds portfolio equity by reinvesting profits, which accelerated 2008 and 2009 returns.



5. MR Swing: Exchange Traded Funds (ETFs)

MR Swing was originally developed for the SPY. We tested the out-of-sample results on other ETFs and found a robust system performance across different geographical and market size index based ETFs.

Table 6: MR Swing (counter) Exchange Traded Funds 07/2000 to 02/2010

	Sym	CAGR	CAGR risk adj	Sharpe	Portfolio Value	Max Wins	Max Losers	Profit Factor	Percent Profitable	Max DD
Emerging Markets	**EEM**	24.76%	25.18%	0.69	$365,399	10	4	1.46	64.46%	37.63%
Russell 2000 Small Caps	**IWM**	14.60%	14.69%	0.60	$322,973	13	4	1.61	65.89%	45.07%
Nasdaq-100 Large Cap	**QQQQ**	36.88%	37.27%	1.12	$2,083,961	10	5	1.74	67.23%	23.16%
Vanguard Total Market	**VTI**	28.56%	28.95%	1.33	$697,403	10	6	2.05	65.51%	19.93%

Next we consider the conservative version that takes no counter-trend trades.

Table 7: MR Swing (no counter) Exchange Traded Funds 07/2000 to 02/2010

Exchange Traded Fund	Sym	CAGR	CAGR risk adj	Sharpe	Portfolio Value	Max Wins	Max Losers	Profit Factor	Percent Profitable	Max DD
Emerging Markets	EEM	4.59%	8.82%	0.19	$130,031	8	5	1.13	60.00%	41.83%
Russell 2000 Small Caps	IWM	13.70%	27.10%	0.78	$301,865	10	4	2.07	68.15%	27.68%
Nasdaq-100 Large Cap	QQQQ	29.25%	66.90%	1.28	$1,196,429	9	4	2.29	72.28%	15.93%
Vanguard Total Stock Market	VTI	16.40%	34.84%	1.07	$323,548	8	4	2.27	66.43%	13.57%

Notice again the out-of-sample ETF results of the no-counter system show much lower max drawdown, and still a solid rate of return. Max consecutive losing trades of both aggressive and conservative systems are between 4 and 6, making this a tradable system. In particular, QQQQ shows a 29% compound annual growth rate (CAGR), 1.28 Sharpe, 77% profitable trades, and 16% max drawdown.

6. MR Swing: Managed Futures

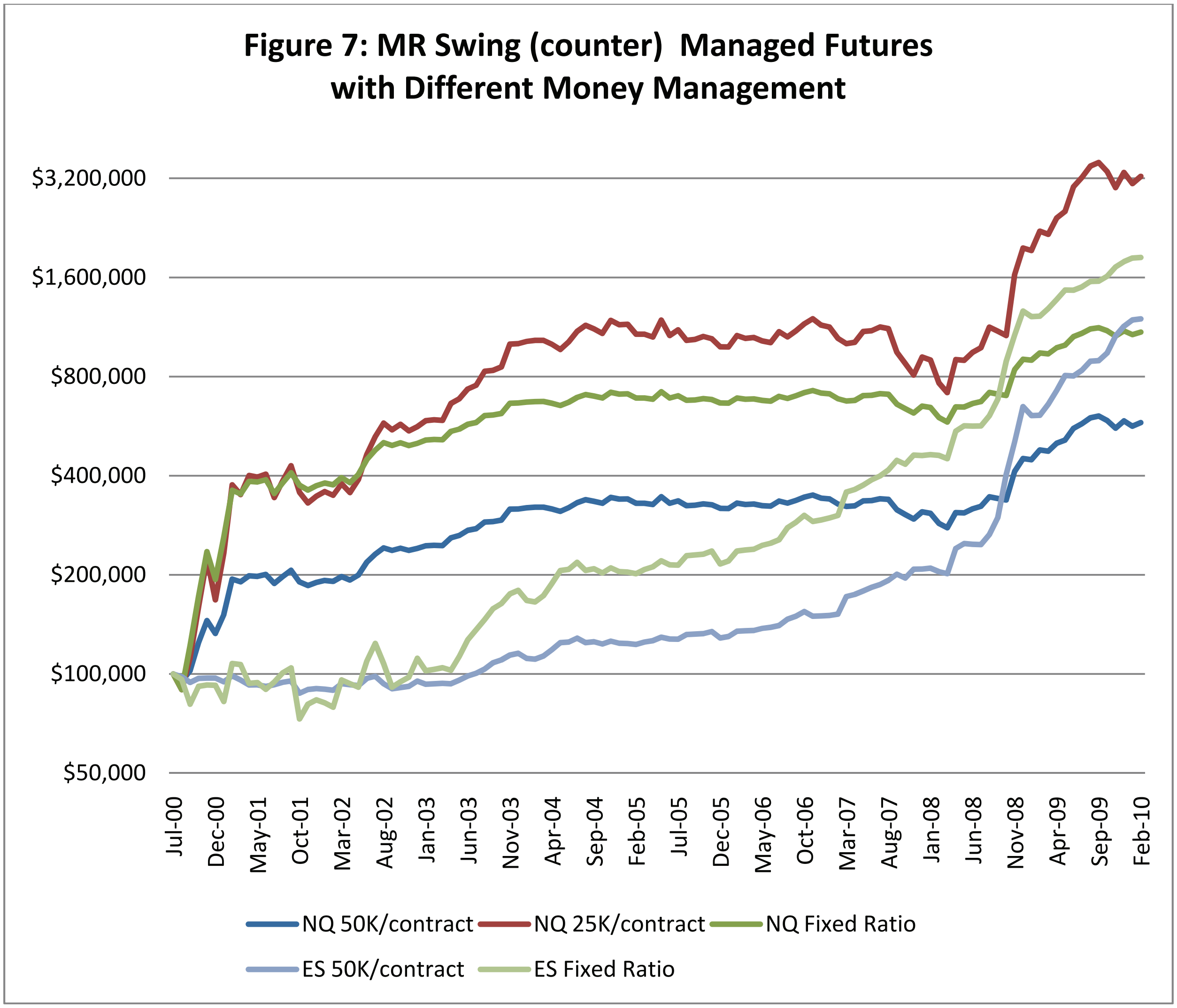
We tested MR Swing on out-of-sample data on the @ES and @NQ futures contracts. Futures provide the benefits of excellent liquidity, low cost commissions, flexible use of leverage, and tax advantages over ETFs (e.g. mark-to-market results 60% long-term capital gains and 40% short-term). One important difference in trading futures is our limit orders for entries and exits may get filled in overnight trading. We have found that overnight order fills to be another positive for trading MR Swing in a managed future account.

Fixed fractional (FF) money management is used at $50,000 per contract, and also $25,000 per contract. That means the system starts trading 2 contracts and 4 contracts respectively. The fixed ratio money management system trades aggressively for a small account then gets more conservative as the account size grows. For example, $10,000 gets one contract. Then it needs 20K for the next contract. At 30K it is trading 2 contracts, and needs 30K more in profit for the third contract, etc.

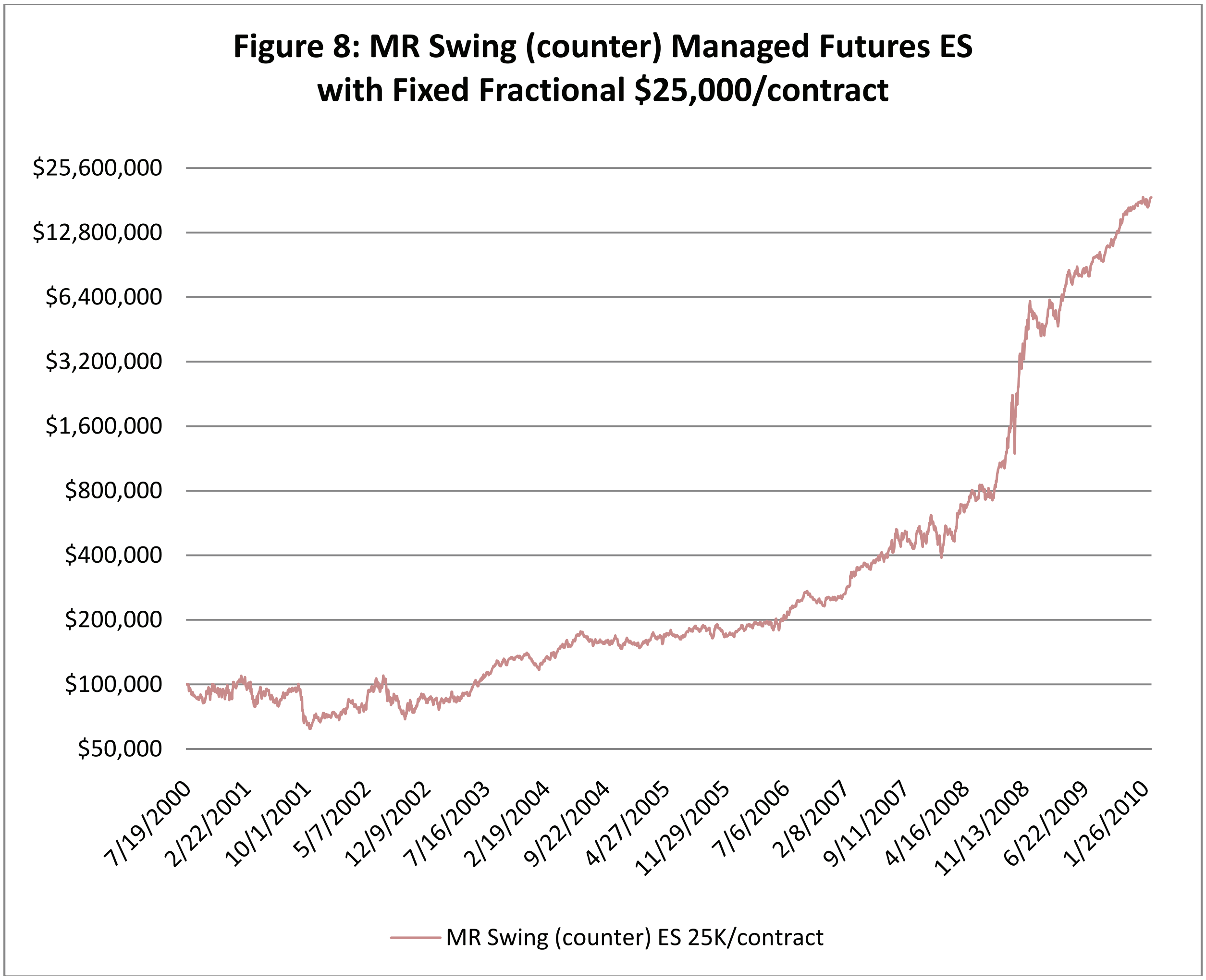
Table 8: MR Swing (counter) $100,000 portfolio from 07/19/2000 to 02/22/2010

Sym	Money Mgt	CAGR	CAGR risk adj	Sharpe	Portfolio Value	Max Wins	Max Losers	Profit Factor	Percent Profitable	Max DD
ES	Fixed Ratio	34.76%	35.41%	1.14	$1,839,589	14	4	2.56	67.75%	46.43%
ES	F F 50K/ctr	28.96%	29.49%	1.26	$1,197,509	14	4	3.18	67.75%	22.24%
ES	F F 25K/ctr	70.12%	71.59%	1.28	$17,892,862	14	4	4.60	67.75%	46.59%
NQ	Fixed Ratio	28.01%	28.26%	0.89	$1,091,448	9	4	1.68	68.41%	33.84%
NQ	F F 50K/ctr	19.90%	20.07%	0.95	$579,387	9	4	1.72	68.41%	21.37%
NQ	F F 25K/ctr	43.26%	43.66%	0.98	$3,243,852	9	4	1.74	68.41%	42.09%

The aggressive version of MR Swing on the ES and NQ contracts with fixed fractional and fixed ration money management is shown below. We included $2.30 per contract for commissions.



One would expect the 25K/contract results to be approximately twice the 50K/contract system. Our tests showed 70.12% CAGR vs. 28.96% CAGR. Since twice the 50K/contract results would be 60%, where did the extra 10% come from? This is due to the interval. A $100,000 portfolio has to accumulate another $50,000 before trading a 3rd contract. The 25K/contract system more quickly adds contracts. Notice in the chart below the growth of the 25K/contract system, compounding 70% per year turns a $100,000 portfolio into $17.8M over ten years. We leave this as an option for the aggressive traders interested in MR Swing.

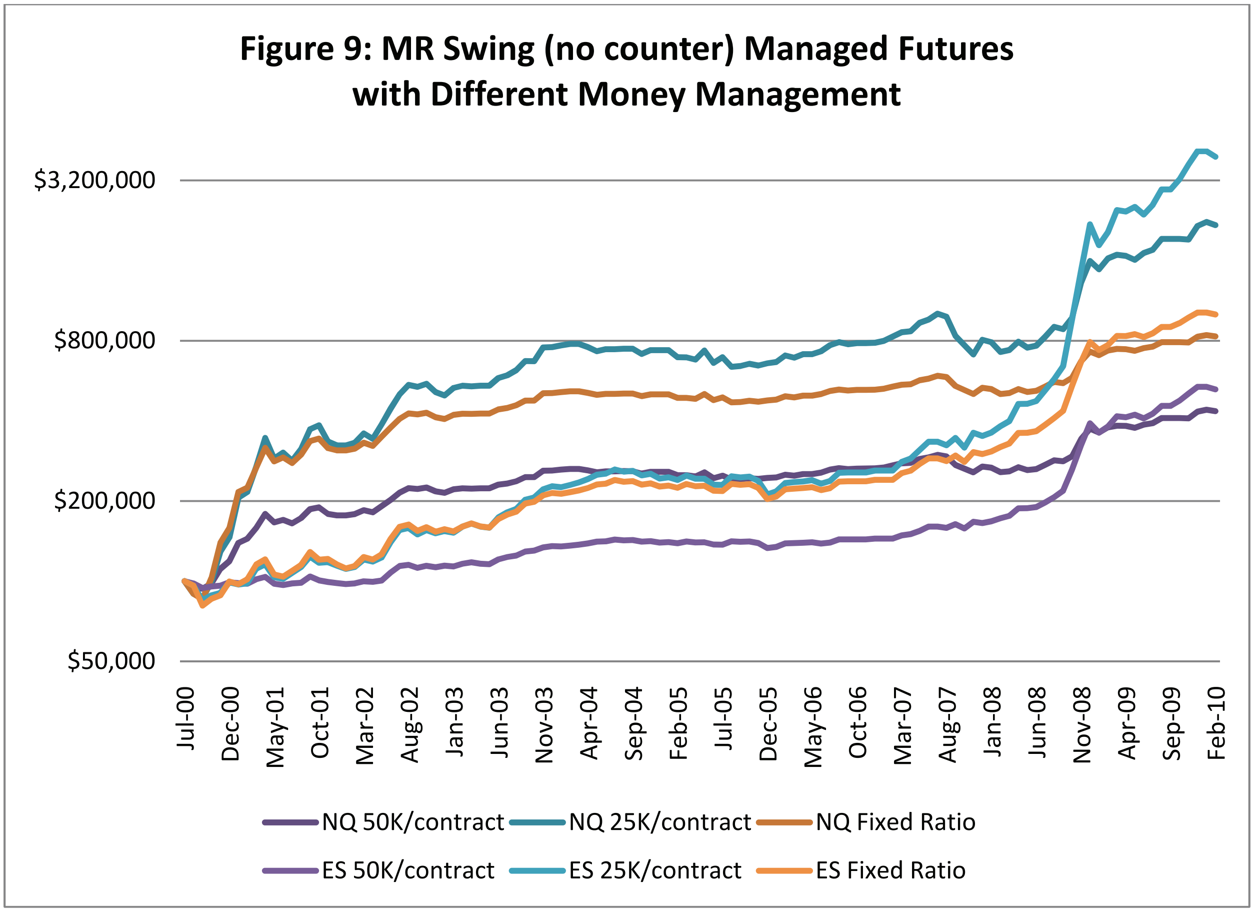


In the next section, we will show how MR Swing can be used to make a much more conservative system that still gives solid returns.

Table 9: MR Swing (no counter) $100,000 portfolio from 07/19/2000 to 02/22/2010

Sym	Money Mgt	CAGR	CAGR risk adj	Sharpe	Portfolio Value	Max Wins	Max Losers	Profit Factor	Percent Profitable	Max DD
ES	Fixed Ratio	26.66%	57.22%	1.21	$1,004,598	18	4	3.03	70.59%	23.20%
ES	F F 50K/ctr	18.52%	38.45%	1.11	$525,439	18	4	3.50	70.59%	10.71%
ES	F F 25K/ctr	45.65%	105.41%	1.23	$3,927,298	18	4	4.48	70.59%	21.86%
NQ	Fixed Ratio	24.46%	50.61%	0.98	$831,042	11	4	2.44	74.77%	29.06%
NQ	F F 50K/ctr	16.41%	32.89%	1.04	$435,128	11	4	2.51	74.77%	16.38%
NQ	F F 25K/ctr	37.45%	81.38%	1.12	$2,173,202	11	4	2.57	74.77%	34.23%

The conservative version of MR Swing in a managed futures account shows exciting results. In particular, we can pick a low-drawdown version of 50K/contract (10.71% for ES, 16.38% for NQ) and still get excellent annual returns (18.52% CAGR for ES, 16.41% CAGR for NQ). Further, if we use leverage on the conservative system, 25K/contract, we double our max drawdown, and get even more than 2X the performance (45.65% CAGR for ES, 37.45% CAGR for NQ).



7. Creating Portfolio Synergy

Modern Portfolio Theory asserts that assembling diversified assets with low or negative correlations creates a portfolio of collectively lower risk without sacrificing return; effectively a "free lunch". The Ivy Portfolio (Faber and Richardson 2009) illustrated a mean-variance portfolio that uses non-correlated indexes to produce a much better absolute and risk adjusted return. The asset allocations are modeled after the Harvard and Yale endowments, which invest more heavily in real assets (commodities and real-estate), absolute returns funds, and private equity than traditional stock heavy portfolios. Additionally, The Ivy Portfolio showed that combining low correlated assets with long term timing rules both increased return **and** decreased volatility over a buy and hold strategy of the same assets.

Lintner (1983) wrote: "the combined portfolios of stocks (or stocks and bonds) after including judicious investments … in leveraged managed futures accounts show substantially less risk at every possible level of expected return than portfolios of stocks (or stocks and bonds) alone." We demonstrate how combining and employing a set of non-correlated strategies achieves substantial improved returns **and** lower drawdowns. To achieve this we substitute a 20% portion of portfolio assets to our MR Swing trading system for the absolute return portion of the endowment's asset mix. Integrated into the base allocation of the Ivy Portfolio, this raises the CAGR by a factor of 1.7 while cutting the maximum drawdown by 3/5ths compared to the Ivy ETFs with Timing returns.

7.1 Ivy Portfolio

In order to compare the Ivy Portfolio with timing to MR Swing and a blended approach, we first align data and time periods. The Ivy Portfolio is based on a basket of equally weighted indexes:

1. United States equity market (S&P 500)
2. Morgan Stanley Capital International EAFE Index (MSCI EAFE),
3. Goldman Sachs Commodity Index (GSCI),
4. National Association of Real Estate Investment Trusts Index (NAREIT),
5. United States government 10-year Treasury bonds

To facilitate back-testing comparisons with our models on a comparable basis, we test the concepts against tradable market instruments. To that end, we identified the following instruments for our version of the Ivy Portfolio.

Table 10: Ivy Portfolio Instruments

1. Vanguard 500 Index Investor (VFINX)
2. Vanguard Total International Stock Index (VGTSX)
3. Thomson Reuters/Jefferies CRB Index, a commodity price index[1]
4. Vanguard REIT Index (VGSIX)
5. Vanguard Intermediate-Term Bond Index (VBIIX)[2]

Tradable ETF's used to construct the Ivy Portfolio. The testing period covers 8/1/2000 through 1/29/2010.[3]

We modeled an ETF version of The Ivy Portfolio for buy-and-hold, with an equal allocation of funds per asset and a yearly rebalance period. We compared that to the Ivy Portfolio using basic timing rules: The asset's portion of the portfolio is fully invested in the asset when the closing price is above the 10 month moving average; it goes to cash when it is below. Cash is modeled at the 30 day T-Bill average of approximately 2.2% and we include normal commissions for a direct access broker ($.005/share).

The Ivy Portfolio diversification adds significant value vs. a buy and hold of the S&P 500 in both return and drawdown. After implementing the timing rules with The Ivy Portfolio it increases performance versus Buy & Hold, adding 3.4 to the annualized return each year while dropping the maximum drawdown from 30 to under 12%[4].

Table 11: Ivy Buy & Hold versus Timing Results
8/1/2000 to 12/31/2009

	CAGR	Sharpe	Max DD
SPY (S&P 500) Buy & Hold	-2.48%	-0.16	56.49%
Ivy Buy & Hold	5.05%	0.26	29.83%
Ivy w/Timing	8.45%	0.99	11.65%

[1] The CRB is the only exception of not being directly tradable in this form. Commodity based ETFs/ETNs do not have sufficient history for our purposes, but DBC could be used today (although the problem of roll yield from contango/ backwardation is not solved).
[2] Vanguard Intermediate-Term Bond Index chosen as Treasury ETF with sufficient history not available.
[3] 8/1/2000 is the first period when data is available for all instruments in our systems.
[4] Both the Ivy Buy & Hold and Ivy w/Timing use the instruments from Table 10.

7.2 Integrating Results of Managed Futures into Ivy Portfolio

Measuring the correlations using the monthly delta of the equity curve values, several of the subcomponents of the Ivy Portfolio have low cross correlations, particularly the commodities and the bonds. MR Swing futures components, NQ and ES, balance each other nicely with only an r= 0.39 correlation. Of greater importance, MR Swing components have low and often negative correlations with the Ivy Portfolio components. We will see how these low/negative correlations enhanced the risk based metrics (Sharpe and drawdown) as we put the pieces together to enhance the portfolio's stability.

Table 14: Cross Correlation of Ivy Portfolio Components and MR Swing Futures

	CRB	*VBIIX*	*VFINX*	*VGSIX*	*VGTSX*	*MR Swing @NQ*	*MR Swing @ES*
CRB	1.00						
VBIIX	0.13	1.00					
VFINX	0.24	-0.02	1.00				
VGSIX	0.21	0.16	0.62	1.00			
VGTSX	0.26	0.10	0.89	0.64	1.00		
MR Swing @NQ	-0.14	0.09	-0.37	-0.16	-0.30	1.00	
MR Swing @ES	-0.32	-0.07	-0.47	-0.30	-0.43	0.39	1.00

MR Swing trading the Futures with ES and NQ work well together since they respond differently to market moves, with the Sharpe, maximum drawdown and volatility all improving on the combined basis.

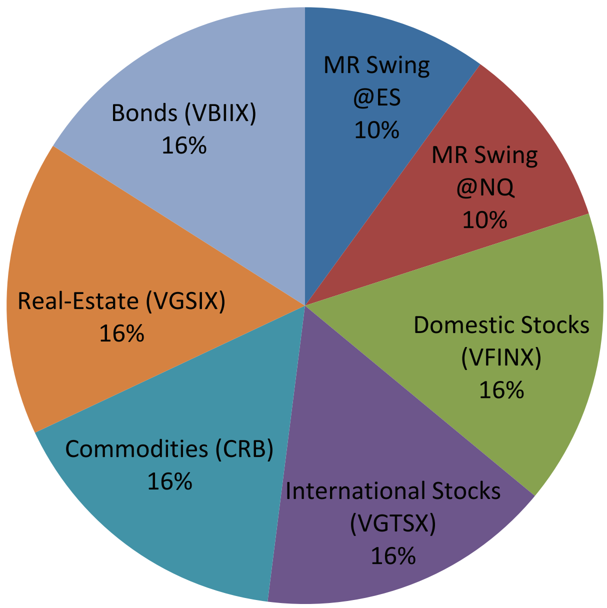
Table 13: Combing Futures - MR Swing (no counter) Fixed Ratio
8/1/2000 to 1/28/2010 [5]

Sym	CAGR	Sharpe	Max DD	Volatility
ES	28.00%	1.25	15.86%	19.2%
NQ	26.42%	1.05	14.65%	20.9%
Combined NQ + ES	27.26%	1.29	11.56%	17.7%

Next, we include the conservative version of MR Swing (no counter) managed futures, with a small 10% allocation each to ES and NQ, using fixed ratio money management into the combined portfolio.

[5] In Tables 11 to 14 the systems are marked-to-market using monthly data (Sharpe, Max DD, and Volatility) to match the rest of the Ivy Portfolio.

Figure 10: Ivy Portfolio + MR Swing

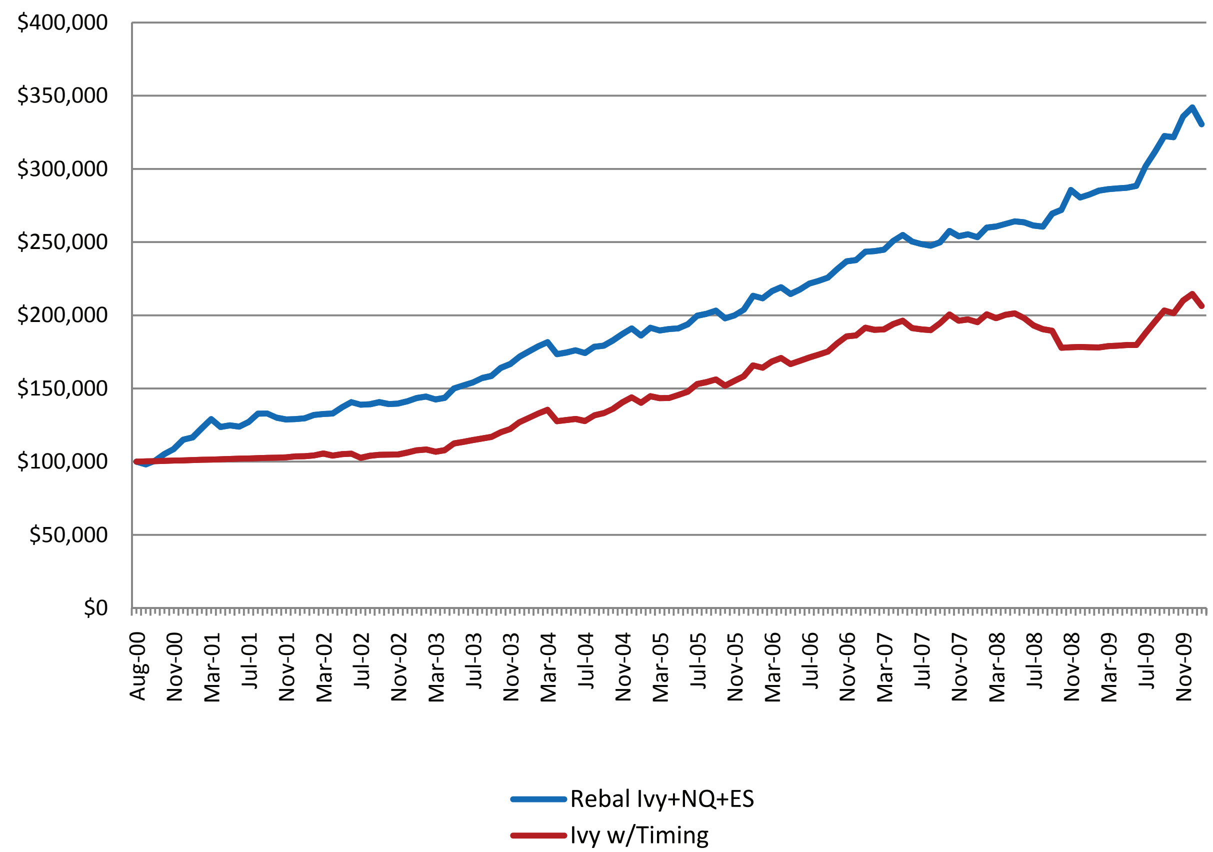


We rebalance back to the 10% allocation to ES and NQ at the beginning of each year. Including a 1/5th allocation to MR Swing into the combined portfolio drives an impressive increase of 5.5 points of CAGR, 0.7 Sharpe, cuts the drawdown by 3/5th, while only increasing volatility by 0.2%!

Table 14: Combing Ivy w/Timing & MR Swing
8/1/2000 to 1/28/2010

Portfolio	CAGR	Sharpe	Max DD	Volatility
Ivy w/Timing	7.92%	0.89	-11.65%	6.6%
Ivy+NQ+ES MR Swing w/Rebalancing	13.41%	1.60	-4.48%	6.8%
Change Due to MR Swing	+5.49	+0.70	+7.17	+0.2

Figure 11: Ivy Portfolio w/Timing vs. Combined Ivy MR Swing



We are not using the Futures to hedge the portfolio, but rather as a source of negatively correlated positive returns. Blending a base of low-correlated assets (The Ivy Portfolio) with a non-correlated, market-regime-switching and volatility adaptive trading system (MR Swing) creates a powerful synergy. The result is superior and safer returns than any of its individual parts.

8. Conclusion

MR Swing is a quantitative system that employs daily mean-reversion and swing trading in different market regimes. Over the last ten years, it showed a robust equity curve (37.90% CAGR, 1.58 Sharpe, 23.65% max drawdown) on the SPY. Removing counter-trend trades cut the maximum drawdown in half and produced excellent risk adjusted returns (23% CAGR, 54% risk adjusted CAGR, 1.37 Sharpe, 13% max drawdown). In addition, MR Swing was tested using managed futures in various money management configurations. The conservative no-counter setup with leverage (25K/contract fixed fractional) produced solid results on the @NQ and @ES (45% CAGR, 105% risk adjusted CAGR, 1.23 Sharpe, 21.86% max drawdown). MR Swing also tested well on a wide range of ETFs.

The system is based on four core principles: (1) a *market-regime-switching* method to exploit different characteristics of markets by using short-term mean-reversion in the bear regime, and deploy swing trading in the bull regime. Next, it uses (2) *non symmetrical trading algorithms* for entries, exits and the regime specific trading algorithms. Every system component is based on (3) *volatility adaptive metrics* that it can handle changes in volatility over a long time span. Finally, since no regime switching model will be able to eliminate all false signals, each core system component exhibits (4) r*obustness to regime whipsaws.*

Finally, we included MR Swing as a 20% component into a diversified portfolio of low correlation ETFs based on the Ivy Portfolio, modeled after university endowments. MR Swing increased the combined portfolio CAGR by a factor of 1.5 while reducing the max drawdown to only 4%. This demonstrates that investors will benefit by including a portion of their funds to a non-correlated systematic approach to smooth and protect their portfolio performance.

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10. Glossary

CAGR	Compound annual growth rate is the smoothed year-over-year growth rate of the system. It covers the entire time period.
CAGR risk adj.	Risk adjusted compound annual growth rate is the year-over-year growth rate of the system, but it only counts time invested in the market.
DVO	David Varadi Oscillator (DVO) measures short term market movements (Varadi 2009)
Fixed Fractional (FF)	Fixed fractional money management is a method of reinvesting profits in a futures trading account (num contracts = Floor(portfolio value / dollars-per-contract)
Fixed Ratio	Fixed ratio money management is a method of reinvesting profits in a futures trading account. The more the portfolio grows the more conservative it becomes in adding new contracts.
Max DD	Maximum percentage drawdown of the system from peak to trough over the time period. In our analysis the equity curve is marked-to-market daily instead of just at the start/end of trades in order to show the true maximum drawdown potential. Only section 7 on the portfolio uses monthly figures because the Ivy Portfolio uses monthly data.
Max Wins	Maximum consecutive winning trades in a row.
Max Losers	Maximum consecutive losing trades in a row.
Percent Profitable	Number of winning trades divided by total number of trades.
Portfolio Value	Value of a $100,000 initial investment after running the system for the period of time.
Profit Factor	Gross profit divided by gross loss. A positive profit factor denotes a net profit per trade on average.
SVAPO	Vervoort's volume and price oscillator is used to find exhaustion points in the bull regime.
Sharpe	Sharpe ratio measures the risk-adjusted performance of the system using monthly data. The risk free rate of return is 2% in our calculations.
Time in Market	The percentage of total time in the market (either long or short), which is not including flat periods between trades.
Volatility	Historic volatility based on Black-Scholes using monthly data in the portfolio section.

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