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The Overlap of Cross Sectional and Time Series Momentum Strategies

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By

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Abstract
This paper contributes to existing literature by providing an analysis of combined time series momentum and cross sectional momentum strategies in the Dow Jones Industrial Average from February, 1991 to December, 2015. Combined momentum strategies are shown to not outperform cross sectional momentum strategies, and all momentum strategies tested are shown to underperform the market index. The twelve month historical return serves as the foundation from which the momentum strategies are formulated. Holding periods discussed in this paper include portfolio's offset by one month from the historical return calculations. Momentum results during the time period analyzed are driven primarily by positive momentum returns, demonstrated in long only position portfolios outperforming short only position portfolios. This paper concludes in line with existing research that momentum portfolios perform best with an offset period due to observed short term momentum reversal. This paper adds a theoretical analysis of the weaknesses associated with pure cross sectional and pure time series momentum strategies, as well as an analysis of the strengths and weaknesses of a combined momentum strategy.

Keywords
Momentum, Time Series Momentum, Cross Sectional Momentum, Combined Momentum Strategies

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Introduction and Literature Review

In academia there have been many studies over momentum within the stock market. Momentum in its purest form refers to the notion that securities that have increased (decreased) in price in the past continue to increase (decrease) in price into the future. Momentum exists in the stock market in two primary forms, cross sectional momentum, and time series momentum. Cross sectional momentum is captured when portfolios are constructed based on a security's historical performance relative to the historical performance of other securities at a given point in time. Time series momentum is captured by comparing the historical return for a security to a previous point in time with respect to that specific security. Academia has primarily focused on cross sectional momentum, while professional literature has primarily focused on time series momentum.

Cross sectional momentum came into the forefront of academic publishing beginning with a study by Jegadeesh and Titman, which found that strategies in which long (short) positions were taken in securities that have performed well (poorly) over the past 3 to 12 month period generated significant positive returns over a 3 to 12 month holding period (Jegadeesh and Titman, 1993). They also found that cross sectional momentum strategies performed best when the holding period was offset from the calculation period by a short term period, with an offset period of one week used in their study. Offsetting the portfolio formation from the historical return calculation period is based on findings in two separate studies by Jegadeesh and Lehmann which identified short-term holding period return reversals that lead to contrarian strategies outperforming in the very short-term, typically a week to a month (Jegadeesh, 1990) (Lehmann, 1990). Long-term holding periods have also been shown to be subject to return reversals in

which winner portfolios significantly underperform loser portfolios when compared over a 3 to 5 year holding period (Lee and Swaminathan, 2000).

Several explanations for the intermediate term returns shown in Jegadesh and Titman's original study have been proposed in academia. Investor reactions to earnings surprises based on a moving average of earnings estimates was shown to generate similar intermediate term returns. However, it was deemed to be only part of the overall component making up these intermediate term returns (Chan, Jegadeesh and Lakonishok, 1996). Industries have been shown to exhibit significant momentum returns over the 1 month to 12 month time period, and are thought to be the source of the momentum returns seen in previous studies over the intermediate term (Moskowitz, Grinblatt, 1999). Even the overall trend in the stock market has been suggested to cause a rising tide carries all boats trend, with momentum returns following positive market periods being positive while the momentum returns following negative market periods being negative (Cooper, Gutierrez, Hameed, 2004). Furthermore a study by Conrad and Kaul proposes that these intermediate returns are explained by the cross sectional variation in the mean returns of the individual securities being considered for the strategy (Conrad, Kaul 1998).

Time series momentum, which focuses on a securities past performance relative to itself as a measure of momentum, has been shown to produce significant positive returns over 1 to 12 month holding periods without any offset periods between the calculation and portfolio formations (Moskowitz, Ooi, Pedersen, 2010). While the academic coverage of time series momentum is rather sparse, time series momentum is covered extensively under the financial field of technical analysis. Time series momentum as represented by technical analysis has a large following in the professional field. A study on mutual funds found that 77% of mutual funds engage in some form of momentum trading (Grinblatt, Titman and Wermers, 1995). When

the study is expanded to a larger pool of institutional investors, it is observed that institutional investors act as momentum based traders when taking positions and act as contrarian traders when exiting or adjusting positions (Badrinath and Wahal, 2002).

When compared to each other, it is found that time series momentum strategies produce superior results to that of cross sectional momentum strategies (Bird, Gao, Yeung, 2011). However, this paper did not find any academic studies under which both strategies were combined. This paper contributes to existing literature by providing an analysis of cross sectional and time series momentum with an offset period of one month. The primary focus of this paper is to analyze the short to near intermediate term returns. This paper also analyzes the strengths and weaknesses to pure cross sectional, pure time series, and combined momentum strategies. A theoretical analysis of the combination of the time series and cross sectional strategies is also contributed to the current literature.

Data Collection and Adjustment

The securities price data used for this paper comes from the CRSP (Center for Research in Security Prices) database, and consists of the 54 securities included in the Dow Jones Industrial Average (DIJA) from January 1st, 1990 to December 31st, 2015. The observed trading period for the strategies is February 1st, 1991 to November 31st, 2015. Prices have been adjusted using the cumulative adjustment factor for prices provided by the CRSP data set. In order to avoid survivorship bias only those stocks that were members of the DJIA at the beginning of the month will be used in any calculations. Due to the offset period in portfolios by a period of one month in order to avoid short term reversals, those stocks that were removed from the DJIA will continue to be tested until the end of the month following their removal. All trades are assumed

to occur at the end of the trading day, and as such the closing price is used for all return calculations. No slippage, transaction fees, or taxes are factored into the trading process and exploration of the validity of momentum strategies under such conditions are left for future research.

Portfolio Construction

Portfolios were constructed by applying criteria to the base calculation of the twelve month historical return. The equation for twelve month historical returns can be seen in Figure 1 on page 15. The twelve month historical return calculation is the same as a typical return calculation with the twelve month return equaling the difference between the current price and the price twelve months ago, divided by the price twelve months ago.

For the cross sectional portfolios the universe of securities was ranked based on their twelve month historical return. The portfolios were formed one month after the twelve month historical return calculation, thus as the first twelve month historical return calculation was calculated on January 1st 1991, the first portfolio was constructed on February 1st, 1991 using the January 1st 1991 rankings. Cross sectional momentum trading rules were to take long (short) positions in securities in the top (bottom) X percentile of the security universe. These trading rules are illustrated in the cross sectional momentum strategy trading rule grid presented in Figure 2 on page 15. All trading grids used throughout this paper were modeled off of the design proposed in a study by Lee, Naranjo, and Sirmans. Multiple cross sectional portfolios were constructed with each positional direction taking one half, one third, one sixth or one tenth of the universe of securities. Once the cross sectional portfolios were constructed, the holding period was for one month after the date of portfolio construction. Only offset portfolios were used for

this study, as non-offset portfolios were tested but found to be statistically insignificant when compared to offset portfolios and this study therefore opted to use offset portfolios found more commonly in academic research.

The time series momentum portfolios were constructed on whether the twelve month historical return value for the security was positive or negative. Within the time series portfolio, long (short) positions were initiated in securities that had positive (negative) twelve month historical return values. The time series trading rule grid is presented in Figure 3 on page 15. This allows the decision on inclusion into the portfolio to be based solely on the historical return of the security relative to itself, and not to the other securities in the considered universe like the cross sectional momentum method.

Forming the combined cross sectional and time series portfolios is based on an overlap of the two individual strategies. As represented in Figure 4 on page 16, the trading rule grid calls for the investor to long (short) securities which have positive (negative) twelve month historical returns and are in the top (bottom) X percent in the ranked universe of securities based on the twelve month historical returns. Using the overlap of the two individual strategies allow the investor to gauge a securities momentum relative to itself and to the relevant universe of securities.

Methodology

The methodology for combining the cross sectional momentum and time series momentum strategy is to decreases the effect of the downsides in each individual momentum method. Cross sectional momentum primarily has two downsides, which stem from the existing

universe of tradable securities and the overall strength of the market during the trading period. As the portfolio size of the cross sectional momentum strategy approaches the size of the universe of tradable securities the cross sectional strategy due to trading a fixed number of securities in each direction has to reach further into the universe of securities lowering the overall performance of the strategy. Cross sectional momentum performs best when the securities in the portfolio are small relative to the tradable securities universe. As the portfolio size expands the probability that the portfolio longs (shorts) a security with weak positive (negative) momentum, or longs (shorts) a security with negative (positive) momentum increases as the portfolio reaches farther out into the universe of securities. The second weakness of the cross sectional momentum strategy occurs during times of extreme market strength and weakness. Theoretically during a time of extreme market strength (weakness) when very few stocks if any are falling (rising) in price, then the cross sectional portfolio's fixed number of short (long) positions would result in shorting (longing) stocks that have been performing well (poorly) in the past.

Time series momentum strategies also suffer from a couple of downsides, principally dealing with the offset of initial portfolio risk, and the portfolio weightings of individual securities. The portfolio composition of the time series momentum strategy allows for an unequal number of positions to be taken in each direction. The cross sectional portfolio does not allow for an unequal number of positions which means that the cross sectional portfolio initially exposes the investor to a net zero risk portfolio while the time series portfolio doesn't have any constraints to ensure this condition. This results in the investor's being exposed to extra risk that is not present in cross sectional portfolios during portfolio creation. The second downfall of time series momentum strategies is that the time series portfolio has no way to measure high and low

performing securities relative to each other. The time series momentum strategy is only concerned with whether the security has a positive or negative historical return. A security that has a 1% twelve month historical return would be treated equally to a security that has a 10% twelve month historical returns. Under a cross sectional momentum strategy, this downfall is not completely eliminated due to overarching market conditions, it is however, less likely that securities with such drastic differences in historical returns will be treated the same due to being ranked against the relative universe of securities.

A combined momentum portfolio allows the investor to minimize the individual downfalls associated with both the cross sectional and time series momentum strategies. The construction of a portfolio that considers both the direction of the historical return (time series momentum) and the return relative to a universe of securities (cross sectional momentum) allows the investor to only long (short) those securities that are outperforming (underperforming) other securities and outperforming (underperforming) relative to itself. Using a combined strategy should lessen the overreach effect when cross sectional portfolios approach the limit of the universe of securities, by only longing (shorting) those securities with positive (negative) historical returns with respect to itself. This eliminates the issue of longing (shorting) the security because of the security's position in the top (bottom) X percent of the tradable securities universe. This also allows the investor to avoid the cross sectional portfolio problem of longing (shorting) a security with negative (positive) historical return because the security would fail the time series criteria of the combined portfolio strategy. The risk present at the creation of the portfolio that was a notable issue with time series portfolios, should be lessened because of the fixed percent range of positions being allowed to be taken in each direction. While a combined momentum portfolio theoretically lessons the downsides of the individual portfolio strategies, it

does not completely eliminate them. Under the conditions of extreme markets trends or approaching the limits of the security universe the downsides should still be present but serve as a lesser degree of hindrance towards the portfolio's performance.

Empirical Results

This paper first analyzes the potential for success when using a combined momentum strategy in the selected securities universe. The long (short) positions in a combined momentum portfolio consist of those securities that fall in both the cross sectional winner (loser) and the time series winner (loser) portfolio. Referring back to Figure 4 on page 16, the long (short) quadrant of the top (bottom) ranking cross sectional momentum securities and the positive (negative) time series momentum securities represents the combined winner (loser) portfolio. To provide the best environment for combined momentum strategies to thrive, the winner (loser) quadrant would provide positive (negative) statistically significant long returns for those securities that fall in each quadrant over the trading time period. Figure 5 presents the monthly long return and the test statistic for each of the four quadrants. All 30 securities within the tradable universe are analyzed as a part of Figure 5 on page 16. The winner quadrant had an average monthly return of .684% and produced statistically significant positive returns on the 1% level. The loser quadrant does not support as strong of conclusions as the winner quadrant. The loser quadrant has a monthly return of .612%, ideally the long return for the loser securities would be negative, however, the monthly return was not statistically significant due to the high standard deviation present in the lower ranked securities.

An analysis of the two cross sectional winner quadrants in Figure 5 provides insight into the effect of combining time series and cross sectional momentum strategies on long only portfolios. A comparison between the time series winner and loser groups within the cross sectional winner quadrants shows that using a time series screen in the long direction results in greater average monthly returns. Figure 6 presents statistics for difference portfolios created from the quadrants presented in Figure 5. The portfolio constructed from subtracting the cross sectional winner time series loser quadrant (CSWTSL) from the cross sectional winner time series winner quadrant (CSWTSW) portfolio highlights the importance of screening for time series momentum when formulating long only portfolios. The CSWTSW – CSWTSL portfolio generates positive statistically significant returns on the 10% level showing that those securities that contain both time series momentum and cross sectional momentum significantly outperform those securities that show cross sectional momentum and negative time series momentum.

The two cross sectional loser quadrants in Figure 5 and the difference portfolio between cross sectional and time series loser securities and the time series winner securities in the cross sectional loser rankings is abbreviated as CSLTSL – CSLTSW, and fails to yield significant returns indicating that within the current universe of securities applying a time series filter to a short cross sectional momentum portfolio does not improve the portfolio's performance. Further evidence that overlaying time series in a short portfolio does not help improve returns is evident in the difference between the combined winner and combined loser portfolio represented in Figure 6 as CSWTSW – CSLTSL. The lack of significance in the difference portfolio is caused by the positive returns seen in the combined loser portfolio. A specific analysis of the individual portfolio follows.

The results of the pure time series, pure cross sectional and the combined cross sectional and time series momentum strategies are presented in Figure 7 on page 18. All strategies are listed with an abbreviated name, the abbreviation CS is cross sectional, TS is time series, CB is combined, and TTMO represents trailing twelve month offset portfolios. The number following the abbreviation represents the maximum number of securities in the portfolio. Only offset portfolios were considered based on the lack of statistical significance between offset and non-offset portfolios. The benchmark that the strategies will be measured to is the pure cross sectional offset 30 security portfolio. A comparison to the market will also be presented in a later section, however, the primary research question is concerned with if combined time series and cross sectional portfolios outperform pure cross sectional momentum portfolios over the time period considered.

The results in Figure 7 include 18 statistically significant strategies, with nine strategies being significant in the positive direction and four strategies being significant in the negative direction. The nine positive statistically significant portfolios were all significant at the 5% level with five of the nine being statically significant at the 1% level. Four of the five negative statistically significant portfolios were significant at the 10% level, with only one being statistically significant at the 5% level with respect to the baseline cross sectional offset 30 security portfolio. Only single directional portfolios were statistically significant, with all the long only directional portfolios having positive significance and five of the short only directional portfolios having negative significance. There is a clear divide between the three types of strategies with the long only strategies performing best, followed by the combined long-short portfolios, with the short only strategies bringing up the rear. The dominance of the long only

directional portfolios suggest that a rising tide carries all boats phenomenon is present in the market over the time period of 1991 to 2015.

Considering only the long directional portfolios, it appears that the fewer the securities the greater the performance and risk assumed by the portfolio. Important to note that the lowest performing long directional portfolio is the time series portfolio which is in-line with expectations during times of market strength. Because the portfolio can only assume long positions, and an overview of the data presents a general trend towards positive returns in the stock market, then merely screening stocks on positive historical returns would be the loosest of the strategies. If momentum is present in the market then stricter strategies should capture more defined momentum, and looser strategies should model the market closer. This is present in the long portfolios as the time series closely models the market and seems to capture less momentum driven returns when compared to the other long only strategies.

The short only portfolios confirm to expectations when dealing with a largely positive market trend. Under a positive market trend, the smaller the portfolio size the better the performance, because fewer stocks will be exhibiting negative momentum in an uptrend. Smaller portfolio sizes increases the odds of having a large portion of the portfolio concentrated in these negative momentum stocks resulting in the best performance in the 5 and 3 security portfolios. The time series portfolio performs in the middle of the pack with respect to the short only portfolios. When compared to a larger portfolio, the time series strategy's ability to vary the number of securities based solely on the direction of historical returns enables the time series strategy to capture more negative momentum than those that are limited to the bottom half of securities. The time series strategy's better performance on the short side also implies that there

is negative momentum present in the top half of the securities that is captured only by the time series strategy.

When comparing the long-short portfolios, the time series and combined 30 security portfolios top the list in terms of monthly return. After the initial top two portfolios there is a trend of the smaller long-short portfolios performing better than the larger portfolios. For the in-depth comparison of the time series, cross sectional and combined portfolios, the 30 security portfolios will be used. The 30 security portfolios were chosen primarily due to the consistency of comparison between the strategies. The comparison of the 30 security portfolios are presented in Figure 8 on page 19. Figure 8 shows the monthly return, standard deviation and test statistic versus the cross sectional portfolio over 5 time periods of 5 years each. A smaller breakdown of the time period provides a clearer picture of the relationship between the strategies throughout the study.

Combined momentum strategies and pure time series strategies seem on first glance to provide some benefits not seen in the cross sectional portfolio, as they both avoid the negative return found in the cross sectional portfolio during 1996- 2000. They also appear to generate greater returns than the cross sectional portfolios on average. The key downside to the combined and time series portfolio is the increased risk taken in these strategies when compared to the cross sectional portfolio. The slight increase in return is offset by the greater increase in risk resulting in the combined and time series portfolios not being statistically significant when compared to the cross sectional portfolio. It is important to note that the combined portfolio underperforms the cross sectional portfolio in two periods, while the time series portfolio always outperforms the cross sectional portfolio.

When the strategies are compared to the risk free rate and the market as in Figure 7, none of the strategies produced statistically significant positive returns when compared to the market. Only the Combined long-short momentum portfolio with 6 securities did not have negative statistical significance with the market out of the long-short and short only portfolios. This is troubling as a majority of the strategies statistically underperform the market indicating that the strategies are unable to utilize momentum to generate positive alphas. When compared to the risk free rate, the cross sectional long only 3 security portfolio is statistically significant on the positive side at the 10% level. Interesting to note the cross sectional momentum strategy with 30 securities statistically underperformed the risk free rate at the 1% level. Further discussion of the significance of these findings is found in the conclusions section that directly follows.

Conclusions

This paper concludes that none of the momentum strategies tested significantly outperformed the market. The lack of significant strategies could be a factor of the universe of securities being limited to the 54 securities, with only 30 possible securities being available to trade at any given time. Further testing of both pure and combined momentum strategies in a larger universe of securities are recommended to determine market significance. An expansion of the securities universe and time period studied could help offset the overall dominant performance of the long only portfolios, as the long only portfolios benefit greatly from the rising tide carries all boats effect that is observed in the market. This paper also finds that combined and time series strategies do not statistically outperform the cross sectional momentum strategies. While both the time series and combined strategies show promise with greater returns,

they also come with greater risk, making the added returns insignificant compared to the cross sectional momentum strategy. Figure 9 on page 20, shows the monthly return series of the 30 security portfolios. This graph demonstrates the added variance in the combined and time series portfolios that results in greater positive returns when the market is positive and greater negative returns when the market is experiencing a crisis. It also demonstrates the similarity of the combined and time series portfolios as both lines follow each other closely. The high correlation between the combined and time series strategies is due to the limiting factor of the security universe size. The cross sectional strategy presents the investor with slightly lower returns, however the decrease in returns is offset by the stability provided in the cross sectional strategy. An analysis of Figure 5 and 6 lends to the conclusion that combining time series momentum and cross sectional momentum, especially in the long direction, could lead to statistically significant positive returns which may extend into the short direction when the universe of securities is expanded. Overall, due to the findings presented in this paper, it is concluded that combining time series and cross sectional momentum does not yield statistically significant positive results that would justify the more complicated portfolio strategy and additional risk taken on in the formation of the portfolio when compared to the pure cross sectional strategy.

Figure 1: Twelve Month Historical Return Equation

$$Twelve\ Month\ Historical\ Return_{it} = \frac{(Price_{it} - Price_{it-12})}{Price_{it-12}}$$

$Price_{it}$ = the price of security i at time t

$Price_{it-12}$ = the price of security i at time t-12

Twelve Month Historical $Return_{it}$ = twelve month historical return of security i at time t

Figure 2: Cross Sectional Momentum Trading Strategy Trading Rule Grid

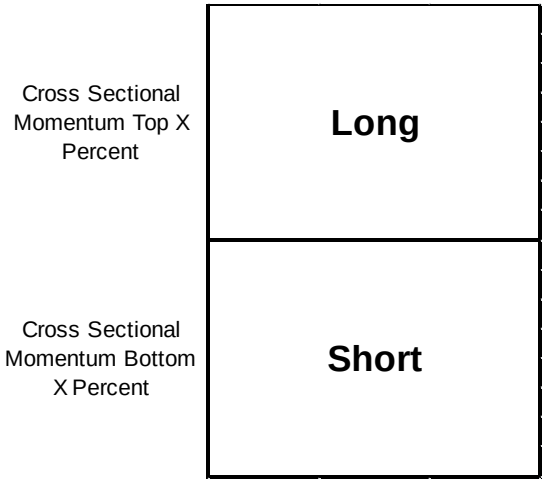


Figure 3: Time Series Momentum Trading Strategy Trading Rule Grid

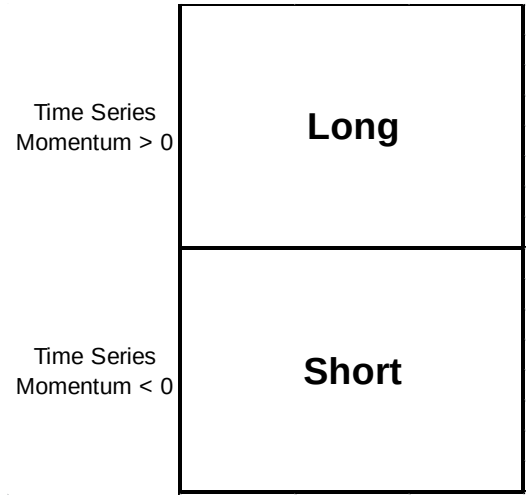


Figure 4: Combined Momentum Trading Strategy Trading Rule Grid

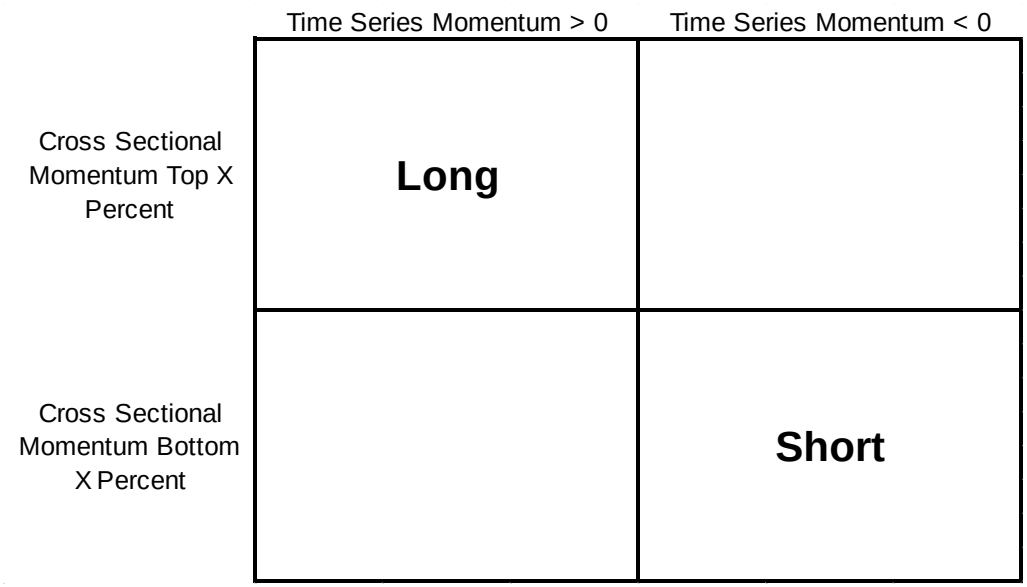


Figure 5: Quadrant Analysis of Combined Winner and Loser Portfolios

	Time Series Winner	Time Series Loser
Cross Sectional Winner	0.684% 2.730***	0.069% 0.347
Cross Sectional Loser	0.525% 2.522**	0.612% 1.605

*The quadrants present the average monthly returns and the test statistic for the combined portfolios. Long only returns used in the formation of the combined portfolios above.

Figure 6: Combined Winner and Loser Difference Portfolio Statistics

	CSWTSW - CSLTSL	CSWTSW - CSWTSL	CSLTSL - CSLTSW
Monthly Return	0.072%	0.615%	0.087%
Standard Deviation	5.252%	4.286%	6.263%
T-Stat	0.235	2.476**	0.2390

*CSWTSW is the first quadrant from Figure 5, the cross sectional winner time series winner portfolio. CSWTSL is the second quadrant from figure 5, the cross sectional winner time series loser portfolio. CSLTSW is the third quadrant from Figure 5, the cross sectional loser time series winner portfolio. CSLTSL is the fourth quadrant from Figure 5, the cross sectional loser time series winner portfolio.

Figure 7: Portfolio Trading Strategies Results

System Name	Monthly Return	Monthly Standard Deviation	Monthly Sharpe Ratio	T-Stat VS CS TTMO 30		T-Stat VS Risk Free Rate		T-Stat VS Market	
CS TTMO 3 L	0.92%	5.21%	0.10	2.89	***	1.72	*	0.75	
CB TTMO 3 L	0.84%	5.26%	0.08	2.62	***	1.46		0.50	
CS TTMO 5 L	0.81%	4.78%	0.09	2.77	***	1.50		0.44	
CS TTMO 15 L	0.78%	4.44%	0.09	2.85	***	1.48		0.34	
CB TTMO 5 L	0.76%	4.81%	0.08	2.57	**	1.31		0.26	
CS TTMO 10 L	0.74%	4.55%	0.08	2.65	***	1.31		0.20	
CB TTMO 15 L	0.68%	4.33%	0.07	2.55	**	1.14		(0.03)	
CB TTMO 10 L	0.67%	4.54%	0.06	2.38	**	1.04		(0.07)	
TS TTMO 30 L	0.61%	4.13%	0.05	2.35	**	0.87		(0.35)	
TS TTMO 30	0.27%	3.63%	(0.04)	1.05		(0.62)		(2.01)	**
CB TTMO 30	0.23%	4.23%	(0.04)	0.74		(0.70)		(1.89)	*
CS TTMO 6	0.19%	4.49%	(0.05)	0.54		(0.81)		(1.94)	*
CB TTMO 6	0.15%	5.70%	(0.04)	0.33		(0.74)		(1.62)	
CB TTMO 10	0.15%	5.12%	(0.05)	0.36		(0.82)		(1.81)	*
CS TTMO 10	0.14%	3.56%	(0.07)	0.46		(1.24)		(2.66)	***
CB TTMO 20	0.11%	4.62%	(0.06)	0.25		(1.06)		(2.16)	**
CS TTMO 30	0.04%	1.91%	(0.18)	-		(3.18)	***	(5.83)	***
CS TTMO 20	0.03%	2.50%	(0.14)	(0.07)		(2.50)	**	(4.52)	***
CB TTMO 5 S	-0.50%	8.49%	(0.11)	(1.10)		(1.82)	*	(2.42)	**
CS TTMO 5 S	-0.53%	8.28%	(0.11)	(1.20)		(1.94)	*	(2.55)	**
CS TTMO 3 S	-0.54%	9.96%	(0.09)	(1.02)		(1.63)		(2.14)	**
CB TTMO 3 S	-0.55%	10.03%	(0.09)	(1.02)		(1.62)		(2.13)	**
TS TTMO 30 S	-0.60%	6.02%	(0.17)	(1.84)	*	(2.86)	***	(3.69)	***
CB TTMO 15 S	-0.62%	6.60%	(0.15)	(1.73)	*	(2.65)	***	(3.42)	***
CB TTMO 10 S	-0.64%	7.15%	(0.15)	(1.65)	*	(2.50)	**	(3.21)	***
CS TTMO 10 S	-0.67%	6.64%	(0.16)	(1.86)	*	(2.78)	***	(3.54)	***
CS TTMO 15 S	-0.69%	5.87%	(0.19)	(2.16)	**	(3.20)	***	(4.06)	***

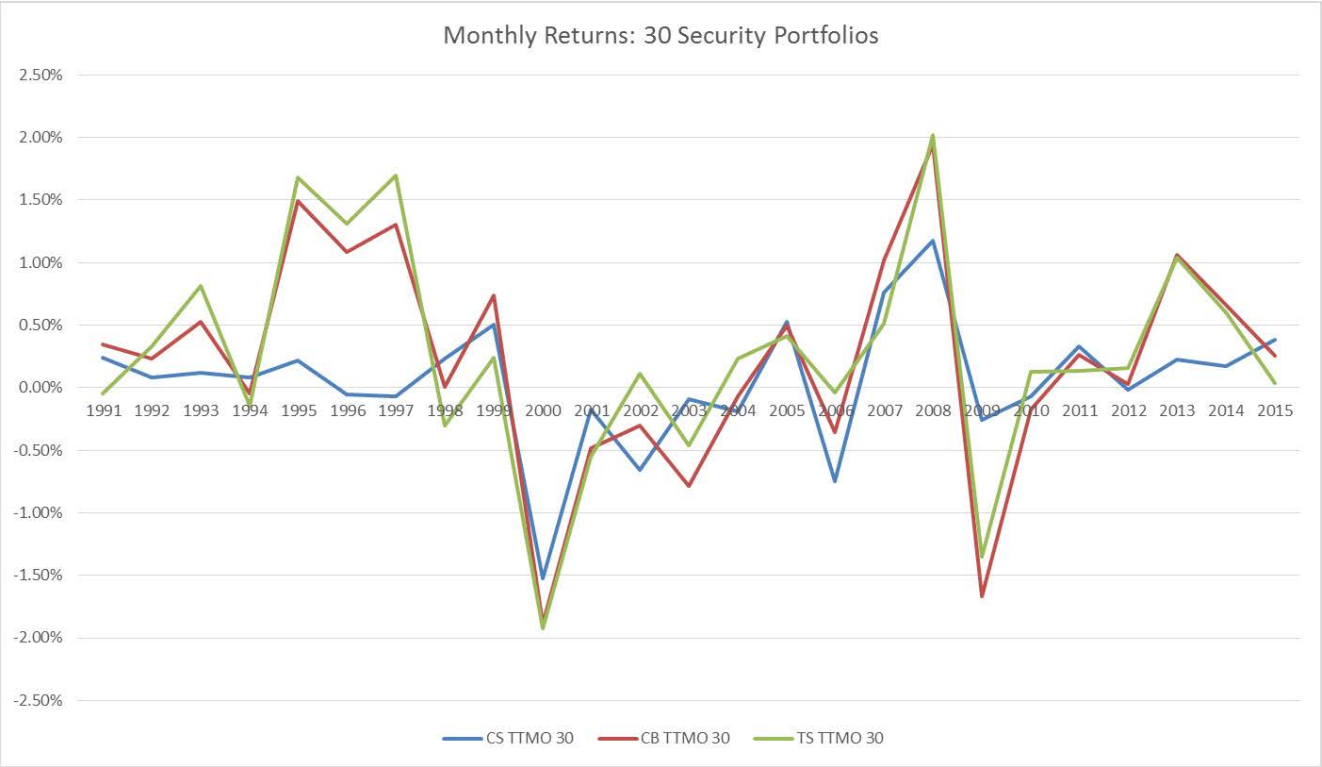
Significance against the Cross Sectional Offset 30 Security portfolio is represented by the stars next to the system name. * 10 % significance, ** 5 % significance, *** 1% significance.

Figure 8: Time Period Analysis of 30 Security Portfolios

Return Series					
	1991-1995	1996-2000	2001-2005	2006-2010	2011-2015
CS TTMO 30	0.146%	-0.184%	-0.117%	0.172%	0.217%
CB TTMO 30	0.513%	0.250%	-0.229%	0.153%	0.457%
TS TTMO 30	0.536%	0.204%	-0.052%	0.254%	0.398%
Standard Deviation					
	1991-1995	1996-2000	2001-2005	2006-2010	2011-2015
CS TTMO 30	1.189%	1.994%	1.546%	3.064%	1.028%
CB TTMO 30	1.889%	3.133%	3.004%	7.906%	2.119%
TS TTMO 30	1.947%	3.359%	2.789%	6.235%	2.098%
T-Stat Versus CS TTMO 30					
	1991-1995	1996-2000	2001-2005	2006-2010	2011-2015
CS TTMO 30					
CB TTMO 30	1.490	1.072	(0.290)	(0.019)	0.872
TS TTMO 30	1.537	0.895	0.180	0.102	0.664

*CS TTMO 30 is the cross sectional portfolio with 30 maximum securities. CB TTMO 30 is the combined portfolio with 30 maximum securities. TS TTMO 30 is the time series portfolio with 30 maximum securities.

Figure 9: 30 Security Portfolio Returns Graph



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