Time-Series Momentum versus Technical Analysis

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Abstract

Time-series momentum and technical analysis are closely related. The returns generated by these two hitherto distinct return predictability techniques frequently have correlations in excess of 0.8. However, despite the similarities, there is a clear pattern of technical trading rules giving larger returns. These rules tend to signal earlier entries into and exits from long positions, which results in meaningful return gains. Both time-series momentum and technical analysis perform best outside of large stock series and both techniques are relatively immune to the crash risk which has been shown to be prevalent in cross-sectional momentum strategies.

JEL Classification: G11, G12
Keywords: Technical analysis, time-series momentum, return predictability

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Abstract

Time-series momentum and technical analysis are closely related. The returns generated by these two hitherto distinct return predictability techniques frequently have correlations in excess of 0.8. However, despite the similarities, there is a clear pattern of technical trading rules giving larger returns. These rules tend to signal earlier entries into and exits from long positions, which results in meaningful return gains. Both time-series momentum and technical analysis perform best outside of large stock series and both techniques are relatively immune to the crash risk which has been shown to be prevalent in cross-sectional momentum strategies.

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1. Introduction

A recent paper by Moskowitz, Ooi, and Pedersen (2012) documents an anomaly called "time-series momentum". They show that past 12-month returns positively predict future returns of the same asset. This is different to the Jegadessh and Titman (1993) momentum anomaly which focuses on cross-sectional return comparisons. Here an asset would be purchased if it was among those with the strongest past returns, even if the asset's price had declined during the evaluation period and the relative out-performance was simply due to its returns being less negative than its peers. In contrast, a time-series momentum strategy would not buy this asset until it had positive past returns. We show that time-series momentum (TSMOM) is closely related to popular moving average technical analysis (TA) rules. These rules involve buying (selling) an asset when its price moves above (below) its average price over the last *n* days.

We test the TSMOM and TA rules on CRSP size quintile indices.[1] Previous empirical tests of TA and TSMOM on equity markets have mostly focused on market indices.[2] However, there is good reason to believe these techniques, which capture price continuation, may be more successful on stocks other than the large stocks which dominate market indices. Merton (1987) suggests investors have less than complete information about all securities and this affects security pricing. We suggest it seems natural to assume this is more prevalent in small stocks. Bhushan (1989) shows analysts focus on large stocks, while Hong, Lim, and Stein (2000, p. 267) suggest "stocks with lower analyst coverage should, all else equal, be ones where firm-specific information moves more slowly across the investing public." More recently, Han, Yan, and Zhou

[1] We thank Ken French for making these data available on his website.
[2] TA examples include Brock, Lakonishok, and LeBaron (1992) for the US and Ratner and Leal (1999) for Asian and Latin American markets. The TSMOM paper of Moskowitz, Ooi, and Pedersen (2012) is also based on equity indices / futures contracts on these indices. A TA exception is Lo, Mamaysky, and Wang (2000) who consider US stocks from different size quintiles.

(2012) find that size and volatility indices are closely related and that TA rules are particularly profitable in volatile assets. This is consistent with Zhang (2006) who finds that greater information uncertainty, which can be measured by the standard deviation of returns, leads to great short-term price continuation, and is in accordance with the Daniel, Hirshleifer, and Subrahmanyam (2001) suggestion that the returns of firms that are more difficult to value should be more predictable.

The correlation of the returns generated by long-only TSMOM and TA rules are 0.84 or higher. However, while there is a strong relation between the returns from TSMOM and TA rules, there is a consistent pattern of TA rules generating larger returns. These results are not inconsistent. The average monthly return on cross-sectional momentum winner stocks over the 1963 – 2011 period is 1.51% compared to 0.88% for the CRSP value-weighted index. However, the correlation between these two series is 0.85.[3] The TA mean returns are almost always larger than their TSMOM equivalents, the volatility of these returns is lower, and the Sharpe ratio is larger.

We generate Fama and French (1993) / Carhart (1997) four-factor alphas for each of the portfolios. This ensures that any differences in alphas across the size quintile portfolios or between TA and TSMOM within the same size quintile portfolio are not driven by well-known anomalies such as the size, value, or cross-sectional momentum effects. The Jensen's alphas of the TA rules are consistently larger and the alpha differences (TA – TSMOM) are often statistically significant, particularly for rules with short look-back periods on the smaller size quintile series. For example, the monthly alphas on the most small quintile series for look-back periods of 10, 50, and 100 days are 1.60%, 1.17%, and 0.72% respectively for TA rules compared to 1.25%, 0.66%, and 0.27% respectively for TSMOM. Our core results are from

[3] This is based on the cross-sectional momentum winner decile portfolio from Ken French's website.

"long-only" rules which are invested in the market following buy-signals and invested in T-bills following sell-signals. However, we verify our results hold for rules that take short market positions.

We decompose the periods where TA and TSMOM are not in the market together and find periods where either TA or TSMOM enter the market before the other rule are characterised by relative large positive daily returns on average. TA generates earlier buy signals more frequently which contributes to its return advantage over TSMOM. Moreover, TSMOM is more likely to result in a position remaining open longer than TA. When this occurs daily returns are negative on average. The earlier closing of TA positions in these instances is of further benefit to TA. In contrast, on the few occasions when TA signals that long position should remain open for longer daily returns are positive on average. Figures 1a and b give an example of a quicker TA buy signal using S&P 500 data. Price moves above the 200-day moving average (signalling a buy based on technical analysis) much sooner than the point where the 200-day return turns positive (necessary for a time-series momentum buy signal).

[Insert Figures 1a and 1b About Here]

The issue of data snooping is ever present when investigating return predictability. It is always possible that a particular trading rule appears to be profitable by chance when it is applied to a particular data series. Lakonishok and Smidt (1988, p. 404) suggest a good way to avoid this is to test anomalies "in data samples that are different from those in which they were originally discovered." The important technical analysis paper of Brock, Lakonishok, and LeBaron (1992) finds technical trading rules like the ones we apply add value when they are applied to the Dow

Jones Industrial Average (DJIA) over the 1897 – 1986 period. We therefore consider the 1987 – 2011 sub-period to ensure we have an out-of-sample test. The returns to both TA and TSMOM on series other than the large stock series remain statistically significant in this period.[4] TA alphas are larger than their TSMOM equivalents in both sub-periods, however the differences are more marked in the earlier period. Our results are also robust in the ten international markets studied by Rapach, Strauss, and Zhou (2012). While TA and TSMOM both generate statistically significant alphas, there is a consistent pattern of larger alphas to TA.

Daniel and Moskowitz (2011) and Barroso and Santa-Clara (2012) show cross-sectional momentum is susceptible to periods of persistent negative returns. This "crash risk" arises following periods of large market declines when the past loser portfolio (which a momentum investor is short) strongly out-performs the past winner long portfolio. These momentum crash risk papers are related to the work of Cooper, Gutierrez, and Hameed (2004) who show momentum returns are positive (negative) when the past three-year market return is positive (negative). We show that neither TSMOM nor TA rules are very susceptible to crash risk. The worst monthly returns from these rules are rarely much worse than those to a buy-and-hold strategy. The worst TA returns are better than their TSMOM equivalents so there is no evidence that the larger TA alphas are compensation for crash risk.

Our paper contributes to the literature that has followed on from Fama's (1970) work on "weak form" market efficiency – the concept that that past price information cannot be profitably used in investment decision making. Authors have tested this theory using TA rules for decades.[5] Brock, Lakonishok, and LeBaron (1992) and Lo, Mamaysky, and Wang (2000) find evidence in

[4] Sullivan, Timmermann and White (1999) find the Brock, Lakonishok, and LeBaron (1992) rules are not profitable in the 1986 – 1996 period when applied to the DJIA. Our results for the large stock quintile support this result. However, we show there is profitability in the most recent sub-period in the more volatile quintile indices.

[5] As Sullivan, Timmermann and White (1999) note, tests of technical trading rules were being conducted well before the concept of weak form market efficiency was developed.

support of TA in the US, while others, such as Bessembinder and Chan (1995) and Ito (1999), show trading rules add value in emerging markets. However, there are also many papers that suggest TA adds no value (e.g. Jegadeesh (2000)) which raises an interesting puzzle. Why is TA popular with the practitioner community (e.g. Menkoff (2010)) if it does not generate excess returns? Several recent papers have made important contributions to this debate. Neely, Rapach, Tu, and Zhou (2010) find TA rule signals are useful predictors of the equity risk premium and they complement predictions based on fundamental factors. The notion that TA can complement other portfolio decision making rules is also shown in the theoretical model of Zhu and Zhou (2009). Moreover, Han, Yan, and Zhou (2012) consider the cross-sectional profitability of TA rules. Unlike previous papers, which have focused on determining whether the time-series profits of TA on a stock index are greater than those to a buy-and-hold strategy, Han, Yan, and Zhou (2012) show TA is particularly profitable when applied to volatile assets. They also show that trading rule returns are not explained by the Fama and French (1993) three-factor model, investor sentiment, or liquidity and default risks and suggest it may be considered to be a "new anomaly."

In contrast to the voluminous technical trading rule literature, the paper of Moskowitz, Ooi, and Pedersen (2012) is, to our knowledge, the only one to document the profits of TSMOM. These authors show TSMOM is profitable in 58 equity indices, currency, bond, and commodity futures contracts over various start dates from 1965 onwards (the end date is 2009). They find that TSMOM profits have only small loadings on traditional asset pricing factors (such as size, value, and cross-section momentum) and speculators exploit TSMOM profits to the determinant of hedgers.

The rest of this paper is structured as follows: Section 2 contains the data and description of the TA and TSMOM trading rules. The key tests are described and the results are presented and discussed in Section 3. Additional results are presented and discussed in Section 4, while Section 5 concludes the paper.

2. Data and Trading Rules

We use value-weighted size quintile portfolios from Ken French's website for the 1963 – 2011 period for our base tests. As part of our analysis we want to document the similarity and differences between the returns to TSMOM and TA rules across the portfolios of different size after well-known factors like size, value, cross-sectional momentum, and the market factor are accounted for, so we obtain these data from Ken French's website. We also run tests on the ten international markets studied by Rapach, Strauss, and Zhou (2012). These include Australia, Canada, France, Germany, Italy, Japan, the Netherlands, Sweden, Switzerland, and the United Kingdom. The international sample period is 1973 – 2011. The equity index data are Thompson Reuters Datastream indices in local currency, while the T-bill data are from Global Financial Data.

The TA rules and TSMOM rules we study are both easy to implement. The TA rules are the popular "moving average" rules. Our base tests are conducted on what Brock, Lakonishok, and LeBaron (1992) refer to as "variable-length moving average rules". A buy signal is generated on day t when the price (P_t) moves above the simple (moving) average of prices over the period $t-n$ to t ($MA_{t-n,\, t}$), where n is the length of the moving average or "look-back period". This long equity market position is maintained until P_{t+k} moves below $MA_{t-n+k,\, t+k}$. The returns following a buy signal are therefore $R_{t+1}, R_{t+2}, \ldots, R_{t+k+1}$. In our core test, we follow Han, Yan, and Zhou (2011) and invest in the risk-free asset at times when there is no buy signal (i.e. $P_t < MA_{t-n,\,t}$). An alternative approach, which is also applied in the literature, is to take a short position during these times. This assumes that short sale positions can always be entered, which may not be accurate, so we limit our analysis of this approach to a robustness check. We also generate results for what Brock, Lakonishok, and LeBaron (1992) calls a "fixed-length moving average" rule. Here a position is held for a pre-determined number of days regardless of whether price has remained above the moving average of past prices or not.

The TSMOM rule we implement generates a buy signal on day t when the price (P_t) moves above the historical price (P_{t-n}), as such a movement implies a positive return over the $t\text{-}n$ to t look-back period. Similar to the moving average rule, a sell signals occurs when the price moves below the historical price. This results in the returns $R_{t+1}, R_{t+2}, \ldots, R_{t+k+1}$. Our base test involves and investment in the risk-free asset when there is no buy signal ($P_t < P_{t-n}$), however we also test a rule that enters short positions during these periods. This approach is particularly appropriate in markets where short positions are readily established, such as the futures markets studied by Moskowitz, Ooi, and Pedersen (2012). We also test a TSMOM rule that remains in the market for a fixed period regardless of where the current price is in relation to the historical price.

We follow Han, Yan, and Zhou (2012) and Moskowitz, Ooi, and Pedersen (2012) and test rules with a variety of look-back periods. The longest look-back period is 200 days which is consistent with the longest interval in Han, Yan, and Zhou (2012) and similar to the 12-month look-back period that Moskowitz, Ooi, and Pedersen (2012) focus on for the majority of their analysis. We also test periods of 10, 50, and 100 days. A 10-day look-back period is the focus of

Han, Yan, and Zhou (2012). Brock, Lakonishok, and LeBaron (1992) consider periods from 50 to 200 days in their seminal paper.

3. Main Results

3.1. Correlations

In Table 1 Panel A, we report the monthly return correlations of the long-only TA and TSMOM strategies for the four look-back periods we consider (10 days, 50 days, 100 days, and 200 days). The correlations tend to be larger in the small stock portfolio and for the 10-day look-back period. However, the correlations are all high (0.84 and above). It is clear that TA and TSMOM are closely related. The Panel B long-short correlations are lower than their long-only equivalents (0.66 and above) but are still relatively large. They reveal a similar trend with larger correlations being apparent for shorter look-back periods and in the smaller stock portfolios.

In Panel C we provide the holding period correlations. These are identical for the long-only and long-short approaches. The buy and sell signals occur at the same time for both. The only difference between the two is the return that is earned following sell signals. The holding period correlations are relatively high, with the majority being above 0.7. They are typically smaller than the return correlations, especially the return correlations of the long-only strategy, which suggests there are not always large differences between the T-bill and market return in times when either TA or TSMOM has signalled a long equity market position and the other has signalled an investment in the T-bill.

[Insert Table 1 About Here]

3.2. Raw and Risk-Adjusted Returns

Table 2 contains the holding periods, mean returns, volatility of returns, Sharpe ratios, and Jensen alphas for each trading rule across the five portfolios of different size. Both TA and TSMOM rules with shorter look-back periods have shorter holding periods. There is also a trend of longer holding periods for TSMOM rules than their TA equivalents. The average holding periods (in days) across the five size portfolios for 10-day, 50-day, 100-day, and 200-day look-back periods are 8, 22, 31, and 47 for TA compared to 10, 32, 46, and 83 for TSMOM.

The mean monthly returns in Panel B clearly demonstrate that both TA and TSMOM rules generate larger returns on the quintile one portfolio and the smallest returns on the largest quintile five portfolio. The average return across the eight TA and TSMOM rules is 1.64% for the quintile one portfolio compared to 0.77% for the quintile five portfolio. The rules based around shorter look-back periods also produce larger returns than their longer look-back period equivalents. The mean monthly return across the five quintile portfolios for TA and TSMOM is 1.58% for the 10-day look-back period compared to 1.04% for the 200-day look-back period. It is also clearly evident that TA rules consistently generate larger returns than their TSMOM equivalents. This out-performance averages 0.33% in the quintile one series and 0.12% in the quintile five portfolio.

As reported in Panel C, the volatility of the TA returns is also consistently lower than that of their TSMOM equivalents. There is also a consistent trend of increased volatility in rules based on longer look-back periods for both TA and TSMOM. Given the Panel B and C results, the Sharpe ratio results in Panel D naturally follow. TA consistently generates larger Sharpe ratios than TSMOM. Both methods give larger Sharpe ratios when they are applied to smaller stock series and when shorter look-back periods are used. For instance, the Sharpe ratio of TA (TSMOM) for a 10-day look-back period on the quintile one portfolio is 0.47 (0.38) compared to Sharpe ratios for TA (TSMOM) of 0.13 (0.10) for a 200-day look-back period on the quintile five portfolio.

Panel E contains the alphas from the Fama and French (1993) / Carhart (1997) four-factor model. As such, these alphas are net of market, size, value, and cross-sectional momentum effects. These monthly alphas show a similar trend to the Sharpe ratios. TA alphas are consistently larger than their TSMOM equivalents. Moreover, both rules generate larger alphas on the smaller stock portfolios with shorter look-back periods. The monthly TA (TSMOM) alphas for the 10-day look-back period on the quintile one portfolio are 1.60% (1.25%) and these decline to 0.11% (-0.04%) for 200-day look-back periods and the quintile five portfolio. In Panel F we report the statistical significance of the alpha differences (between TA and TSMOM) based on the Wald test in a system of equations approach. These results indicate the statistical significance of the alpha differences is strongest in portfolio one.

In Section 4 we present results which indicate that the conclusions from the Table 2 results are robust in different sub-periods, across the business cycle, in international markets, when short-positions are entered following sell signals, and when positions are held for fixed holding periods.

[Insert Table 2 About Here]

In Figure 2 we plot the returns to a TA, TSMOM, and buy-and-hold investor across the five size portfolios. These show that the TA investor experiences the largest overall returns in the first four size portfolios. The TSMOM investor experiences the next largest, while the buy-and-hold investor has the lowest returns. In the large stock portfolio the TA investor out-performs the buy-and-hold investor but the TSMOM investor does not.

[Insert Figure 2 About Here]

3.3. Return Difference Decompositions

It is clear from the holding period correlations in Table 1 that long market or T-bill positions signalled by TA and TSMOM are consistent the majority of the time. The return differences we document in Table 2 come from periods when one rule has signalled a long market position and the other has not, so we examine these instances in detail in Table 3. Both the TA and TSMOM strategies involve a look-back period of 50 days.[6] Scenario 0 includes days when both TA and TSMOM are long the equity market or invested in the T-bill at the same time. This is the most common situation. For example, in the small stock portfolio scenario 0 occurs in 10,344 out of a total of 11,832 sample days, which represents 87% of the time. Once these situations occur, they last for a relatively long time (28-29 days) and the average return on these days is 0.05%. The days when TA and TSMOM generate different signals can be classified into six mutually exclusive scenarios. Scenarios 1 and 2 are periods when TA (TSMOM) signal long positions first and TSMOM (TA) long position signals follow. Scenario 3 (4) is when TA

[6] We present results for the 50-day look-back period as it is in between the shortest (10 days) and longest (200 days) look-back periods. Results for the other look-back periods are available on request.

(TSMOM) is in the market last following a period when both TA and TSMOM have signalled long positions. Scenario 5 (6) is periods when TA (TSMOM) has signalled long market positions and TSMOM (TA) has not.

In the small stock portfolio the average returns on scenario 1 and 2 days are 0.36% and 0.37% respectively, which are much larger than those in Scenario 0. Establishing a long equity market position early that is subsequently followed by the other strategy leads to positive returns for both strategies. However, the TA rule is far more likely to be in this situation (32% of all days where the strategies signal different positions, compared to just 5% for TSMOM). These periods tend to be relatively short-lived. The average number of days is seven and four for Scenario 1 and 2 respectively. Scenario 3 (4) is when TA (TSMOM) is in the market last following a period when both TA and TSMOM have signalled long positions. It is much more common for TSMOM to stay in the market longer (41% of all days with deviations). Moreover, the market returns are -0.12% on these days on average. Staying in the market longer tends to hurt TSMOM investors. TA is less likely to signal positions staying open longer than TSMOM (just 9% of deviation days). However, when this does occur the returns are positive on average, which further benefits TA. Both Scenario 5 and 6 occur relatively infrequently (7% and 6% of deviation days respectively). However, when they do occur market returns are negative on average (-0.37% and -0.36% respectively).

It is important to note that the returns in Table 3 are not directly comparable to the mean returns in Table 2. The Table 2 returns include those earned from being in the T-bill and they are monthly returns which have been generated from compounding daily returns. However, the Table 3 returns can be used to get insight into the difference between the Table 2 mean TA and TSMOM returns. These differences are most pronounced for the small stock portfolio and the size of the difference decreases monotonically as the portfolio size increases. There is very little difference between the mean TA and TSMOM returns in the large stock portfolio. As such, we would expect the very apparent differences between TA and TSMOM returns in Panel A of Table 3 to reduce in Panels B – E. The results indicate this is the case. The main difference in Panel B over Panel A is that the mean TSMOM return in Scenario 2 is higher. This higher return in periods when TSMOM is first to enter a long position offsets some of the negative relative performance of TSMOM in the other scenarios. It is also clear that the losses from the unique TA signals are larger. However, the net weighted average return, which is obtained by multiplying the unique TA returns by the proportion of times they occur and deducting the product of the unique TSMOM return and the proportion of times they occur, is still relatively large.

There is little change from Panel B to C, but the Panel D results indicate the returns in periods when TA stay in the market longer are negative on average. The Panel E results show that in the large stock portfolio the returns on days when TSMOM stays in the market longer are close to zero rather than negative, which further reduces the TA outperformance.

[Insert Table 3 About Here]

We also investigate whether a combined strategy that only enters and exists positions when both TA and TSMOM are in agreement performs better than individual TA and TSMOM strategies. The Appendix 1 results indicate this is not the case. The mean returns and Jensen Alphas of the combined strategy are typically lower than those for the standalone TA strategy, as documented in Table 2.

3.4. Downside Risk

Daniel and Moskowitz (2011) and Barroso and Santa-Clara (2012) both document that cross-sectional momentum is susceptible “crash risk”. These periods of persistent negative returns can be a substantial risk for cross-sectional momentum investors. In Table 4 we focus on the lowest monthly returns generated by TSMOM (TA) and compare them to the returns experienced by a TA (TSMOM) investor in that same month. We also document the returns a buy-and-hold investor would have earned in each of these months. Finally, we present the returns to TSMOM and TA in the months when the buy-and-hold returns are the lowest. We present results for a look-back period of 50 days for the small portfolio and the middle size portfolio. As documented previously, neither TA nor TSMOM perform well on the large portfolio. The results indicate that neither TSMOM nor TA are particularly susceptible to crash risk. This fact is also evident in Figure 2. It is clear that both TA and TSMOM rules typically move the investor to the T-bill investment prior to sustained market declines. Moreover, the downside returns of TA are less severe than their TSMOM equivalents. Crash risk compensation is not driving the higher TA returns.

The Panel A results indicate the lowest monthly return for TSMOM in the small stock portfolio is -14.01%, which occurred in April 2004. In this month the buy-and-hold return was -13.72%. The TSMOM return is lower because it was invested in T-bills for some of the days in the month where the buy-and-hold investor earned positive (larger) returns from the equity market, but was invested in the equity market on the days when it declined. Of the ten negative TSMOM return months there is never a situation when the buy-and-hold return is positive. The largest underperformance is in May 2010 when the TSMOM return was -12.05% and the buy-and-hold return was -8.02%. There are also several instances where the buy-and-hold return is substantially less than the TSMOM return. The TA returns are typically less negative than their TSMOM equivalents in the months of the ten worst TSMOM returns. TA seems to be less susceptible to crash risk. A similar pattern is evident in the middle quartile results.

The Panel B results relate to the lowest ten TA monthly returns. The worst TA return is a loss of 8.75%, which is clearly a smaller loss than the worst TSMOM monthly loss (-14.01%). Moreover, the TSMOM returns are frequently lower than the TA returns in the same month even though months have been selected on the basis of poor TA performance. This further emphasizes that TA is less susceptible to downside risk than TSMOM.

The Panel C results show that both TSMOM and TA have considerably less downside risk than a buy-and-hold strategy. The lowest buy-and-hold return in the small portfolio was October 1987. In this month the loss was 28.79%. Investors adopting a TSMOM or TA trading rule would have lost less than 1% in this month. In the second worst buy-and-hold return month (August 1998) both TSMOM and TA generated small positive returns.

[Insert Table 4 About Here]

Daniel and Moskowitz (2011) consider market timing and the sources of crash risk in cross-sectional momentum portfolios using a number of models. We apply the logic behind these models to investigate crash risk in both TSMOM and TA. The results are presented in Table 5.

$$r_{P,t} - r_{f,t} = [\alpha_0 + \alpha_B I_B] + [\beta_0 + \beta_B I_B + \beta_{B,U} I_B I_U](r_{m,t} - r_{f,t}) + \varepsilon_t \tag{1}$$

$$r_{P,t} - r_{f,t} = \gamma_0 + \gamma_B I_B + \gamma_{mkt}\sigma_m^2 + \gamma_{highstress} I_B \sigma_{m,t}^2 + \upsilon_t \quad (2)$$

Where[7]:

$r_{P,t}$ is the return on either the TSMOM or TA portfolio in month *t*.

$r_{f,t}$ is the return on the Treasury bill in month *t*.

$r_{m,t}$ is the return on the CRSP VW portfolio in month *t*.

I_B is an ex-ante indicator variable for bear-markets. If the CRSP VW index return is negative (positive) in the prior 24 months prior to month *t*, the variable is 1 (0).

I_U is contemporaneous up-month indicator variable. If the CRSP VW index return is positive (negative) in month *t*, the variable is 1 (0).

σ_m^2 is an ex-ante market volatility estimate for the next month. We use the standard deviation of the CRSP VW index return over the 50 days prior to month *t*.

[Insert Table 5 About Here]

The conditional CAPM in equation 1 examines the alpha and beta differences in bear markets versus other periods. For the TSMOM portfolio, the alpha difference between the bear period and other period, α_B, is not significantly different from zero in any of the size quintile portfolios. The change in alphas driven by the bear period is also insignificant for the size quintile 1 and 2 portfolios for the TA rule. However, the impact of the bear period significantly reduces the alphas of the medium and large size TA portfolios.

[7] See Daniel and Moskowitz (2011) for more detail on these variables.

During the bear period, the betas have a statistically significantly decline across all size quintile portfolios for both TSMOM and TA, which indicates that the portfolio returns become less sensitive to the downside market movement. This implies that the TSMOM and TA portfolios tend to switch to the T-bill during bear periods. The coefficient $\beta_{B,U}$ captures the market timing of TSMOM and TA portfolios. The significantly positive $\beta_{B,U}$ suggests that the portfolio exposure increases with the contemporaneous positive market movement. This confirms the market timing ability of both TSMOM and TA portfolios.

Equation 2 examines the impact of market stress on the TSMOM and TA portfolios. We find no evidence that either TA or TSMOM are adversely affected by the market stress. Both rule returns are not significantly explained by the ex-ante market volatility. When the market volatility is high and in the bear periods, the estimated coefficients $\gamma_{highstress}$ in all size quintile portfolios are not statistically different from zero, so both TSMOM and TA are immune to the high market stress periods.

4. Additional Results

4.1. Sub-Period, Business Cycle, and Prior Market Return Results

We test the robustness of our claims, based on the full-sample Table 1 and 2 results, in different periods in Table 6. We consider two sub-periods, recessions and expansions, and periods where the previous 36-month market return has been positive and negative. The most recent sub-period of 1987 – 2011 is chosen to ensure we have an “out-of-sample” period that follows the 1887 – 1986 period used by the important moving average technical analysis paper of Brock, Lakonishok, and LeBaron (1992). Lakonishok and Smidt (1988) note that testing anomalies in datasets that differ from those in which they were first documented in is an effective tool in combating data mining bias.[8] Henkel, Martin, and Nardari (2011), Dangl and Halling (2012), and Rapach, Strauss, and Zhou (2012) all find that predictability relations vary across the business cycle. The ability of a range of economic and financial variables to predict equity market returns appears to be stronger in recessions than expansions. Cooper, Gutierrez and Hameed (2004) find the profits to cross-sectional momentum are dependent on the state of the market. Cross-sectional momentum is only profitable if the market has been going up over the previous 36 months. They note that investors will likely be more overconfident following positive market returns and, consistent with Daniel, Hirshleifer, and Subrahmanyam (1998), this increased overconfidence leads to larger momentum profits. The results we present relate to look-back period of 50 days. We choose this period as it is in between a shortest and longest period and is used in the Brock, Lakonishok, and LeBaron (1992) paper.

The Panel A results show the correlations are large in the early sub-period and the more recent one, in recessions and expansions, and in periods when the previous 36-month return has been both positive and negative. The correlations are marginally larger in the earlier sub-period (average = 0.87) than the more recent period (average = 0.83). The recession correlations average 0.77 which is lower than the expansion average of 0.86. Finally, the correlations are slightly larger in periods when the market increased over the previous 36 months (average = 0.85) than when the previous 36-month return was negative (average = 0.82).

Both TSMOM and TA are profitable in both sub-periods. The alphas are consistently positive and statistically significantly different from zero in all but the large stock portfolio. The lack of robust predictability for TA in the recent period for the large stocks is consistent with

[8] The international market results we generate also address this issue.

Sullivan, Timmermann and White's (1999) finding that moving average trading rules do not add value in the 1986 – 1996 period when applied to the DJIA. TA alphas are larger than their TSMOM equivalents in both sub-periods. These differences are statistically significant for the first four portfolios in the 1965 – 1986 period and for the small portfolio in the 1987 – 2011 period.

In Panel B we report alphas for both TSMOM and TA in NBER recessions and expansions. Both the TSMOM and TA alphas are larger in recessions than expansions. However, the statistical significance of the TSMOM alphas is stronger in expansions. These alphas are clearly more volatility in recessions. Moreover, the differences between the TA (TSMOM) alphas across recessions and expansions are only statistically significant at the 10% level or stronger in the least two small portfolios respectively. These are denoted with a # in Panel C. TA alphas are consistently larger than their TSMOM equivalents in both recessions and expansions. However, these differences are only statistically significant in expansions for the three smaller portfolios.

The Panel C results indicate that, in contrast to cross-sectional momentum, both TSMOM and TA tend to be more profitable when the market has fallen over the last 36 months. TA generates larger alphas in both periods. However, the difference between the TA and TSMOM alphas is only statistically significant when the market has been up over the previous 36 months.

[Insert Table 6 About Here]

4.2. International Results

We repeat our core analysis for the ten international markets considered by Rapach, Strauss, and Zhou. (2011). These are Australia, Canada, France, Germany, Italy, Japan, the Netherlands, Sweden, Switzerland, and the UK. The results are for the long-only strategy and a look-back period of 50 days. The Table 7 Panel A results indicate the correlation between TA and TSMOM returns are large in each market. The correlations range from 0.86 in The Netherlands to 0.90 in Canada and Sweden.

The average holding periods are longer for the TSMOM rule than the TA rule, which is consistent with the US results. Mean returns to TA rules are larger than those to TSMOM for each country, which is also in accordance with the US results. However, unlike the US results, there are also instances where volatility is larger for TA than TSMOM. This occurs in four of the countries. All the Sharpe ratios are, however, larger for TA than TSMOM. The Jensen Alphas are highly statistically significant for both TA and TSMOM across all countries. These range from 0.31% per month to 0.78% per month, and are a similar magnitude to those for the middle quintile size and second largest size portfolio in the U.S. There is a pattern of higher alphas for TA than TSMOM for each country. However, these differences are not statistically significant.

[Insert Table 7 About Here]

4.3. Short Position Results

If TA and TSMOM are as effective at signalling declines in the equity market as they are at signalling equity market increases then entering short equity market positions following market declines rather than investing in the T-bill generate larger returns than those in our base tests. In other words, the gains from short positions in the long / short approach will exceed the returns from being in T-bills in the long-only approach. The Appendix 2 results show that both TA and TSMOM do typically generate larger returns when short positions are permitted. In particular, the scenarios where the largest returns are generated, such as the 10-day look-back on the small portfolio, show a marked increase.

The TA (TSMOM) monthly Jensen's Alpha increases from 1.60% (1.25%) in the long-only scenario to 3.07% (2.35%) in the long / short approach. Lower returns are generated by long / short rules for some longer look-back rules on smaller stock portfolios. However, what is clear is that the relation between TA and TSMOM returns for any given size portfolio and look-back period are very similar regardless of whether the long-only or long / short settings are used. TA rules consistently have larger returns, larger Sharpe ratios, and larger Jensen alphas than their TSMOM equivalents. The statistical significance of the Jensen alpha differences also shows the same pattern of being stronger for rules with shorter look-back periods on smaller portfolios. Given that the similarities and differences between TA and TSMOM are the focus of this paper, we take the conservative approach of focusing on long-only returns for the remainder of the paper. As many authors (e.g., Barberis and Thaler (2002)) note, short-selling constraints often limit the ability of investors to take short positions in reality.

4.4. Breakeven Transaction Costs

The focus of our paper is on comparing and contrasting TA and TSMOM rather than quantifying the economic significance of these strategies. However, we do generate estimates of the one-way break-even transaction costs.[9] Consistent with other researchers in this area (see Han, Yan, and Zhou (2012) page 14 for a review), we assume that transaction costs are incurred each time the stock index is bought or sold but no transaction costs are incurred when changes are made to the T-Bill position. The Appendix 3 results show the breakeven transaction costs are considerably larger on the first four size portfolios, which is consistent with the results in Table 2. In the small stock portfolio the TSMOM (TA) breakeven costs range from 96 (95) basis points for rules with a 10-day look-back period to 385 (367) basis points for rules with a 200-day look-back period. In the second to largest stock portfolio TSMOM (TA) breakeven costs range from 51 (58) basis points for rules with a 10-day look-back period to 289 (233) basis points for rules with a 200-day look-back period. Transaction costs vary through time and differ based on investor type, so we do not conduct a more comprehensive analysis of the economic significance of TA and TSMOM in this paper. However, we do note that authors, such as Balduzzi and Lynch (1999), use transaction costs estimates of 50 basis points for direct investment in NYSE and Nasdaq stocks and 1 basis point for investments via futures contracts.

[9] We calculate these by starting with the total return generated by each rule over the 1965 – 2011 period (see Figure 2) and then determining the level of transaction costs that would, based on the number of trades for each rule, reduce these returns to zero.

4.5. Fixed Holding Period Results

Another approach to implementing TA and TSMOM is to hold positions for a fixed period, ignoring any sell signals that occur before the end of this period. This period is the minimum holding period as a buy signal at the end of this period would result in the position being maintained. i.e., in reality, an individual would not sell a position one day and open a new position on that day. Rather, they would just keep their position open. Brock, Lakonishok, and LeBaron (1992) also test such a strategy, which they refer to as a "fixed-length moving average" approach, alongside the more flexible holding period approach we use for our base tests and did not find material differences between the two. We present results for a 50-day look-back period and a ten-day holding period in Appendix 4. These results are very similar to those in Table 2 in that TA consistently has higher returns, Sharpe ratios, and Jensen alphas than TSMOM. We therefore focus on the results where the holding period is determined by the rule itself rather than some arbitrary pre-determined period.

4. Conclusions

Technical analysis and time-series momentum have developed as two separate parts of the return predictability literature. Popular technical trading rules include those based on moving averages, where a buy signal is generated when the price moves about the average historical price over a defined number of days. Time-series momentum rules generate buy signals when the return over a past period is positive. This is distinct from cross-sectional momentum which generates buy signals based on the return of a security relative to the return of other securities.

We show moving average technical trading rules and time-series momentum rules are closely related. The returns generated by each method frequently have correlations that are in excess of 0.8. These large correlations are evident in different sub-periods, recessions and expansions, periods when the market has been increasing and declining, and in international markets. There are, however, important differences between the two. TA rules tend to generate larger returns, larger Sharpe ratios, and larger Jensen Alphas than their TSMOM equivalents. TA rules are more likely to signal a buy signal sooner and exit long positions more quickly, which lead to larger returns on average.

Unlike cross-sectional momentum, neither TA nor TSMOM are particularly susceptible to crash risk. Both these rules exit long positions prior to sustained market downturns. TA rules are better at this than their TSMOM equivalents so there is no evidence that larger returns accruing to TA are compensation for higher crash risk.

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Table 1
Time-Series Momentum and Technical Analysis Correlations

	Q1 (Small)	Q2	Q3	Q4	Q5 (Large)
	Panel A: Return Correlations - Long Only				
10	0.94	0.89	0.89	0.89	0.86
50	0.90	0.88	0.89	0.88	0.84
100	0.90	0.90	0.88	0.86	0.88
200	0.88	0.86	0.84	0.87	0.88
	Panel B: Return Correlations - Long / Short				
10	0.86	0.77	0.76	0.75	0.70
50	0.77	0.76	0.77	0.75	0.66
100	0.78	0.78	0.75	0.69	0.76
200	0.72	0.68	0.66	0.73	0.75
	Panel C: Holding Period Correlations				
10	0.77	0.74	0.74	0.72	0.72
50	0.75	0.73	0.71	0.70	0.68
100	0.70	0.66	0.68	0.69	0.69
200	0.70	0.69	0.69	0.69	0.78

Data are CRSP quintile value-weighted size portfolios for the 1963 – 2011 period. Panel A contains monthly correlations of the returns produced by the long-only TSMOM and TA strategies for the four look-back periods (ranging from 10 days to 200 days). Equivalent correlations for TSMOM and TA strategies that take a short position following sell signals are in Panel B. Panel C contains correlations for the holding periods. Holding periods are the same for both long-only and long-short approaches.

Table 2
Time-Series Momentum and Technical Analysis Performance and Comparison

	Q1 (Small)		Q2		Q3		Q4		Q5 (Large)	
	TA	TSMOM	TA	TSMOM	TA	TSMOM	TA	TSMOM	TA	TSMOM
Panel A: Holding Periods										
10	9	10	8	9	8	9	8	9	7	8
50	28	32	25	25	22	25	20	24	16	18
100	41	46	33	37	28	38	29	32	24	27
200	61	83	47	81	40	82	46	67	43	65
Panel B: Mean Returns										
10	2.37	2.04	2.01	1.68	1.90	1.43	1.68	1.28	0.89	0.57
50	1.95	1.55	1.64	1.27	1.45	1.21	1.30	1.10	0.78	0.71
100	1.58	1.27	1.34	1.05	1.23	1.14	1.12	1.04	0.78	0.79
200	1.34	1.06	1.14	0.98	1.09	1.06	1.11	0.96	0.86	0.80
Panel C: Volatility										
10	4.14	4.20	3.89	3.96	3.47	3.61	3.35	3.39	2.96	2.99
50	4.12	4.20	3.95	3.90	3.66	3.58	3.42	3.44	3.00	3.17
100	4.23	4.43	4.04	4.16	3.71	3.77	3.54	3.67	3.02	3.18
200	4.40	4.70	4.19	4.47	3.84	4.08	3.53	3.88	3.20	3.56
Panel D: Sharpe Ratios										
10	0.47	0.38	0.41	0.31	0.42	0.28	0.37	0.25	0.16	0.04
50	0.37	0.26	0.30	0.21	0.28	0.22	0.25	0.19	0.12	0.08
100	0.27	0.19	0.22	0.15	0.21	0.18	0.19	0.16	0.12	0.11
200	0.20	0.13	0.17	0.12	0.17	0.15	0.19	0.14	0.13	0.10
Panel E: Jensen Alphas										
10	1.60***	1.25***	1.30***	0.97***	1.22***	0.76***	1.03***	0.61***	0.32***	-0.03
50	1.17***	0.66***	0.90***	0.46***	0.71***	0.43***	0.60***	0.33***	0.18**	0.06
100	0.72***	0.27*	0.51***	0.13	0.47***	0.25**	0.39***	0.17	0.13	0.07
200	0.32***	-0.09	0.19	-0.12	0.18	0.01	0.25***	-0.02	0.11	-0.04
Panel F: Jensen Alpha Difference p-value										
10	0.04		0.05		0.00		0.00		0.01	
50	0.00		0.00		0.07		0.07		0.36	
100	0.01		0.03		0.15		0.15		0.65	
200	0.02		0.06		0.29		0.07		0.27	

Data are CRSP quintile value-weighted size portfolios for the 1963 – 2011 period. Panel A contains average holding periods in days. The TA and TSMOM strategies involve investing in the equity market (T-bill) following a buy (sell) signal. The mean, and standard deviation of monthly returns are in Panels B and C respectively. Panel D contains monthly Sharpe ratios while Panel C contains monthly alphas based on the four-factor model. Statistical significance at the 10%, 5%, and 1% level (based on Newey and West (1987) standard errors) are denoted by *, **, and *** respectively. The p-values from a test of the statistical significance of the differences in TA and TSMOM alphas are provided in Panel F.

Table 3
Time-Series Momentum and Technical Analysis Difference Decomposition

Scenario	0	1	2	3	4	5	6
Panel A: Q1 (Small)							
Number of Instances	345	66	19	49	138	34	33
Number of Days	10344	479	76	129	611	101	92
Proportion of Daily Deviations		32%	5%	9%	41%	7%	6%
Average Return	0.05	0.36	0.37	0.13	-0.12	-0.37	-0.36
Panel B: Q2							
Number of Instances	416	76	20	70	166	32	46
Number of Days	10280	455	68	180	645	98	106
Proportion of Daily Deviations		29%	4%	12%	42%	6%	7%
Average Return	0.05	0.40	0.59	0.13	-0.08	-0.51	-0.33
Panel C: Q3							
Number of Instances	441	81	26	70	159	51	49
Number of Days	10204	478	59	161	595	164	171
Proportion of Daily Deviations		29%	4%	10%	37%	10%	11%
Average Return	0.05	0.36	0.86	0.02	-0.10	-0.45	-0.11
Panel D: Q4							
Number of Instances	481	87	25	63	191	57	52
Number of Days	10168	473	86	150	654	148	153
Proportion of Daily Deviations		28%	5%	9%	39%	9%	9%
Average Return	0.05	0.35	0.57	-0.06	-0.06	-0.49	-0.23
Panel E: Q5 (Large)							
Number of Instances	592	80	43	105	215	68	76
Number of Days	10045	357	97	261	705	184	183
Proportion of Daily Deviations		20%	5%	15%	39%	10%	10%
Average Return	0.04	0.29	0.73	0.08	0.00	-0.40	-0.35

Data are CRSP quintile value-weighted size portfolios for the 1963 – 2011 period. The TA and TSMOM strategies involve a look-back period of 50 days and investing in the equity market (T-bill) following a buy (sell) signal. Scenario 0 is when both TA and TSMOM are long the equity market or T-bill at the same time. Scenario 1 (2) is periods when TA (TSMOM) signal long positions first and TSMOM (TA) long position signals follow. Scenario 3 (4) is when TA (TSMOM) is in the market last following a period when both TA and TSMOM have signalled long positions. Scenario 5 (6) is periods when TA (TSMOM) has signalled long market positions and TSMOM (TA) has not. “Number of Instances” and “Number of Days” are the number of occasions that each scenario occurs and the total number of days of each scenario. The “Proportion of Daily Returns” is percentage of total days across scenarios 1-6 that each scenario represents. The “Average Return” is the average daily return (as a percentage) across the days in each scenario.

Table 4
Worst Month Performance

Panel A: Rank by TSMOM

Q1 (Small)				Q3			
Date	TSMOM	TA	BH	Date	TSMOM	TA	BH
200004	-14.01	0.46	-13.72	200809	-12.71	-12.83	-10.07
201005	-12.05	-7.11	-8.02	199902	-9.67	-5.45	-7.55
198003	-11.48	-1.89	-17.81	200102	-8.51	-6.50	-6.71
200809	-10.17	-7.18	-8.18	197311	-8.43	-2.61	-16.79
200003	-9.58	-8.75	-9.58	200901	-7.84	-14.69	-8.17
200910	-8.33	-2.55	-8.33	200711	-7.74	-5.31	-5.54
197010	-7.84	-7.50	-7.84	200004	-6.87	0.46	-4.71
197910	-7.22	-2.67	-10.49	198012	-6.79	-3.58	-2.50
196911	-6.90	-5.37	-6.90	198607	-6.69	-3.55	-8.12
197311	-6.79	-2.17	-19.10	197910	-6.60	-3.07	-9.13

Panel B: Rank by TA

Q1 (Small)				Q3			
Date	TSMOM	TA	BH	Date	TSMOM	TA	BH
200003	-9.58	-8.75	-9.58	200901	-7.84	-14.69	-8.17
197010	-7.84	-7.50	-7.84	200809	-12.71	-12.83	-10.07
200809	-10.17	-7.18	-8.18	201005	-6.30	-8.44	-7.06
201005	-12.05	-7.11	-8.02	199710	-4.13	-6.93	-4.13
200804	0.29	-6.56	1.54	200102	-8.51	-6.50	-6.71
200903	0.02	-6.05	9.22	201111	-0.60	-5.48	-0.21
197308	-6.21	-6.04	-5.62	199902	-9.67	-5.45	-7.55
199710	-3.02	-5.61	-3.02	200501	-6.15	-5.37	-2.98
196605	-6.71	-5.42	-11.18	200711	-7.74	-5.31	-5.54
196911	-6.90	-5.37	-6.90	200212	-4.84	-5.18	-4.84

Panel C: Rank by BH

Q1 (Small)				Q3			
Date	TSMOM	TA	BH	Date	TSMOM	TA	BH
198710	-0.51	-0.27	-28.79	198710	-1.06	0.72	-26.13
199808	0.42	0.42	-21.45	199808	0.42	0.42	-19.91
197810	-5.25	-1.89	-20.47	200810	0.09	0.09	-19.05
200810	0.09	0.09	-19.65	197810	-2.14	0.45	-16.93
197311	-6.79	-2.17	-19.10	197311	-8.43	-2.61	-16.79
198003	-11.48	-1.89	-17.81	198003	-4.20	1.20	-15.45
197004	0.51	0.51	-17.47	197004	0.51	-0.89	-14.18
200207	0.15	0.15	-14.41	200109	0.29	0.29	-13.85
200004	-14.01	0.46	-13.72	199008	0.67	0.67	-11.86
199008	0.67	0.67	-13.06	201109	0.00	0.00	-11.37

Data are CRSP quintile value-weighted size portfolios for the 1963 – 2011 period. The TA and TSMOM strategies involve a look-back period of 50 days and investing in the equity market (T-bill) following a buy (sell) signal. Panel A contains the lowest ten monthly returns for the TSMOM strategy and the corresponding TA and buy-and-hold returns. Panel B contains the lowest monthly returns for the TA strategy and the corresponding TSMOM and buy-and-hold returns. The lowest ten monthly buy-and-hold returns and corresponding TSMOM and TA returns are in Panel C. Each part of the analysis is conducted separately for the small and middle stock portfolios.

Table 5
Crash Risk

	Market Timing			Market Stress	
	TSMOM	TA		TSMOM	TA
			Panel A: Q1 (Small)		
α_0	0.008***	0.011***	γ_0	0.007	0.007
α_B	0.002	0.000	γ_B	-0.024	-0.014
β_0	0.552***	0.516***			
β_B	-0.231	-0.247*			
$\beta_{B,U}$	0.140	0.367			
			γ_{sd}	0.075	0.148
			$\gamma_{highstress}$	0.497	0.379
Adjusted R^2	0.306	0.318		0.001	0.008
			Panel B: Q2		
α_0	0.005***	0.009***	γ_0	0.006	0.008
α_B	-0.005	-0.010	γ_B	-0.022	-0.018
β_0	0.589***	0.559***			
β_B	-0.408***	-0.363**			
$\beta_{B,U}$	0.367	0.592**			
			γ_{sd}	0.052	0.065
			$\gamma_{highstress}$	0.439	0.412
Adjusted R^2	0.396	0.410		-0.001	0.001
			Panel C: Q3		
α_0	0.005***	0.007***	γ_0	0.006	0.006
α_B	-0.006	-0.015***	γ_B	-0.022	-0.023
β_0	0.580***	0.564***			
β_B	-0.398***	-0.430***			
$\beta_{B,U}$	0.388*	0.692***			
			γ_{sd}	0.032	0.079
			$\gamma_{highstress}$	0.454	0.444
Adjusted R^2	0.462	0.482		0.000	0.000
			Panel D: Q4		
α_0	0.003***	0.006***	γ_0	0.005	0.004
α_B	-0.003	-0.016***	γ_B	-0.024	-0.017
β_0	0.588***	0.547***			
β_B	-0.391***	-0.457***			
$\beta_{B,U}$	0.361*	0.786***			
			γ_{sd}	0.016	0.082
			$\gamma_{highstress}$	0.523	0.359
Adjusted R^2	0.517	0.536		0.003	0.001
			Panel E: Q5 (Large)		
α_0	0.000	0.001	γ_0	0.003	0.004
α_B	-0.005	-0.011***	γ_B	-0.020	-0.015
β_0	0.583***	0.496***			

β_B	-0.531***	-0.424***			
$\beta_{B,U}$	0.414**	0.591***			
			γ_{sd}	-0.023	-0.042
			$\gamma_{highstress}$	0.434	0.364
Adjusted R^2	0.550	0.526		0.001	0.001

Data are CRSP quintile value-weighted size portfolios for the 1963 – 2011 period. The TA and TSMOM strategies involve a look-back period of 50 days and investing in the equity market (T-bill) following a buy (sell) signal. The equation specifications are as per Daniel and Moskowitz (2011). Statistical significance at the 10%, 5%, and 1% level (based on Newey and West (1987) standard errors) are denoted by *, **, and *** respectively.

Table 6
Performance and Comparison by Period

Panel A: Correlations

	1965 - 1986	1987 - 2011	Recession	Expansion	36 Month Up	36 Month Down
Q1 (Small)	0.88	0.82	0.76	0.86	0.84	0.84
Q2	0.89	0.83	0.77	0.86	0.85	0.83
Q3	0.87	0.83	0.77	0.86	0.86	0.82
Q4	0.87	0.83	0.76	0.87	0.86	0.82
Q5 (Large)	0.85	0.83	0.79	0.85	0.86	0.77

Panel B: Jensen Alphas by Time Period

	1965 - 1986		1987 - 2011		TSMOM v TA p-values	
	TSMOM	TA	TSMOM	TA	1965 - 1986	1987-2011
Q1 (Small)	0.68***	1.35***#	0.61***	1.01***#	0.01	0.10
Q2	0.67***#	1.24***#	0.30*#	0.64***#	0.02	0.15
Q3	0.58***	1.07***#	0.32**	0.45***#	0.02	0.56
Q4	0.49***	0.89***#	0.26*	0.40***#	0.04	0.48
Q5 (Large)	0.10	0.36**	0.04	0.06#	0.16	0.93

Panel C: Jensen Alphas by Business Cycle

	Recession		Expansion		TSMOM v TA p-values	
	TSMOM	TA	TSMOM	TA	Recession	Expansion
Q1 (Small)	0.67	1.44***	0.64***	1.08***	0.18	0.01
Q2	0.70*	1.21***	0.38***	0.82***	0.39	0.01
Q3	0.65	1.09***	0.36***	0.62***	0.42	0.09
Q4	0.58	1.04***#	0.26**	0.49***#	0.35	0.12
Q5 (Large)	0.34#	0.63**#	-0.04#	0.06#	0.48	0.47

Panel D: Jensen Alphas by Up and Down Markets

	Previous 36 Month Up		Previous 36 Month Down		TSMOM v TA p-values	
	TSMOM	TA	TSMOM	TA	36 Month Up	36 Month Down
Q1 (Small)	0.63***	1.07***	0.84**	1.55***	0.01	0.18
Q2	0.47***	0.93***	0.62**	0.78**	0.01	0.75
Q3	0.43***	0.73***	0.64**	0.66**	0.07	0.96
Q4	0.30***#	0.57***	0.69**#	0.69**	0.07	0.99
Q5 (Large)	-0.02#	0.12#	0.58**#	0.48**#	0.32	0.81

Data are CRSP quintile value-weighted size portfolios for the 1963 – 2011 period from Ken French's website. The TA and TSMOM strategies involve a look-back period of 50 days and investing in the equity market (T-bill) following a buy (sell) signal. Panel A contains return correlations by sub-period, NBER business cycle, and market return over the prior 36 months. Monthly alphas, based on the four-factor model, are in Panels B-D. Statistical significance at the 10%, 5%, and 1% level (based on Newey and West (1987) standard errors) are denoted by *, **, and *** respectively. p-values from a test of the statistical significance of the differences in TA and TSMOM alphas are also provided. We also run a t-test to determine whether the difference TA (TSMOM) alpha in the two sub-periods, in recessions and expansions and in previous up and down markets is statistically significant. Those that are (at the 10% level or stronger) are denoted by a #.

Table 7
International Evidence

	Australia	Canada	France	Germany	Italy	Japan	Netherlands	Sweden	Switzerland	UK
					Panel A: Correlations					
Return	0.87	0.90	0.88	0.87	0.89	0.87	0.86	0.90	0.87	0.89
Holding Period	0.75	0.76	0.77	0.77	0.73	0.77	0.76	0.84	0.77	0.68
					Panel B: Holding Periods					
TSMOM	26	27	25	25	25	25	24	38	26	22
TA	21	23	23	23	22	22	19	29	22	19
					Panel C: Mean Returns					
TSMOM	1.26	1.10	1.17	0.90	1.41	0.78	1.08	1.72	0.95	1.29
TA	1.41	1.26	1.38	1.09	1.67	0.83	1.05	1.73	1.02	1.41
					Panel D: Volatility					
TSMOM	3.81	3.23	4.30	3.47	5.47	3.48	3.53	4.72	3.08	3.92
TA	3.88	3.18	4.30	3.41	5.50	3.43	3.52	4.90	2.99	4.25
					Panel E: Sharpe Ratios					
TSMOM	0.132	0.148	0.126	0.139	0.105	0.147	0.176	0.265	0.218	0.155
TA	0.363	0.396	0.320	0.321	0.304	0.243	0.297	0.354	0.341	0.332
					Panel F: Jensen Alphas					
TSMOM	0.35***	0.33***	0.31***	0.33***	0.44***	0.44***	0.40***	0.77***	0.45***	0.33***
TA	0.50***	0.49***	0.51***	0.52***	0.70***	0.49***	0.37***	0.78***	0.53***	0.43***

International results are calculated for the countries studied by Rapach, Strauss, and Zhou. (2011). Equity data are obtained from Thompson Reuters Datastream. T-Bill Data are from Global Financial Data. The data covers the 1973 – 2011 period. Returns are in local currency. The results are for the long-only strategy and a look-back period of 50 days. Statistical significance for Jensen Alphas based on the market model at the 10%, 5%, and 1% level (based on Newey and West (1987) standard errors) are denoted by *, **, and *** respectively.

Figure 1
S&P 500 Index - 200-day Moving Average Trading Rule

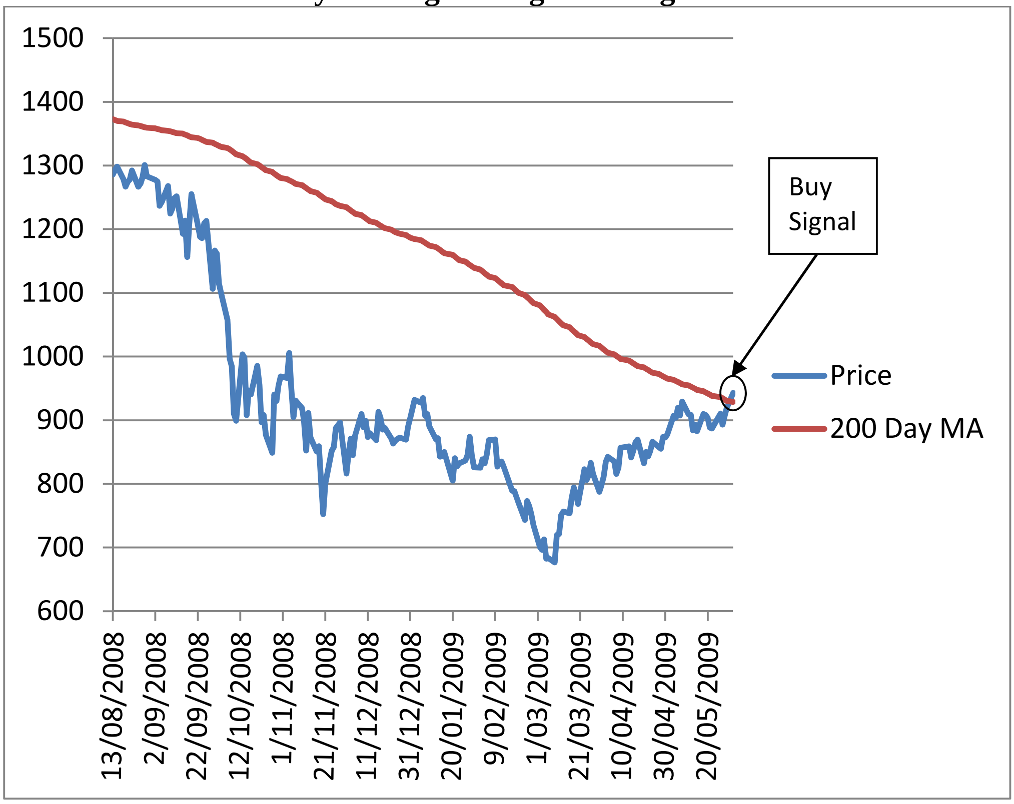


Figure 1b: S&P 500 Index - 200-day Time Series Momentum Trading Rule

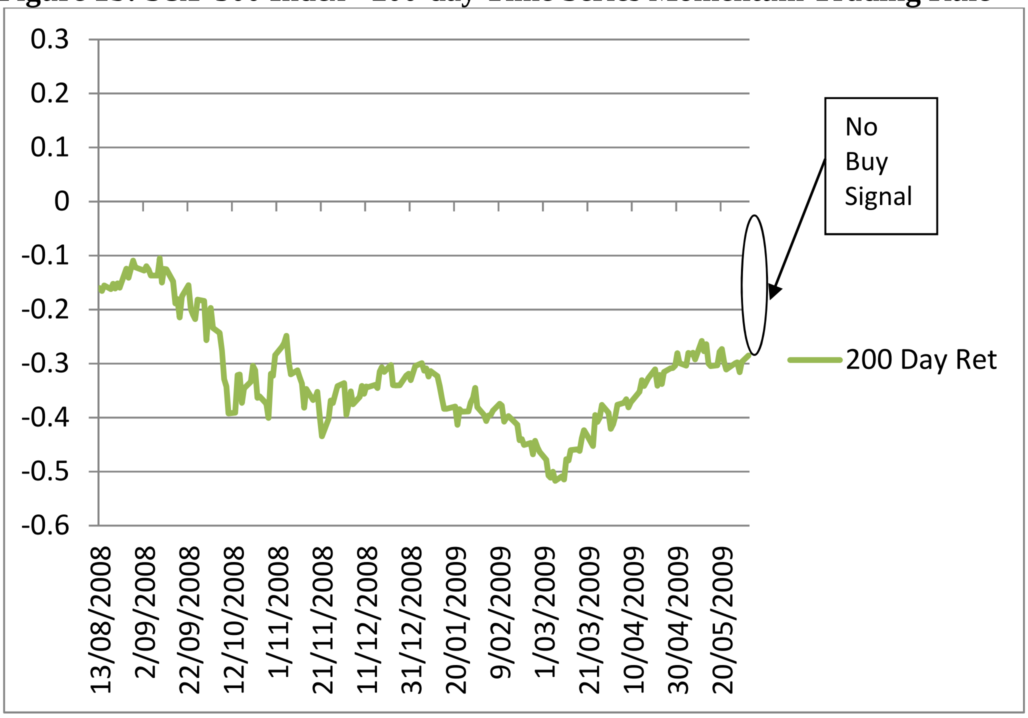
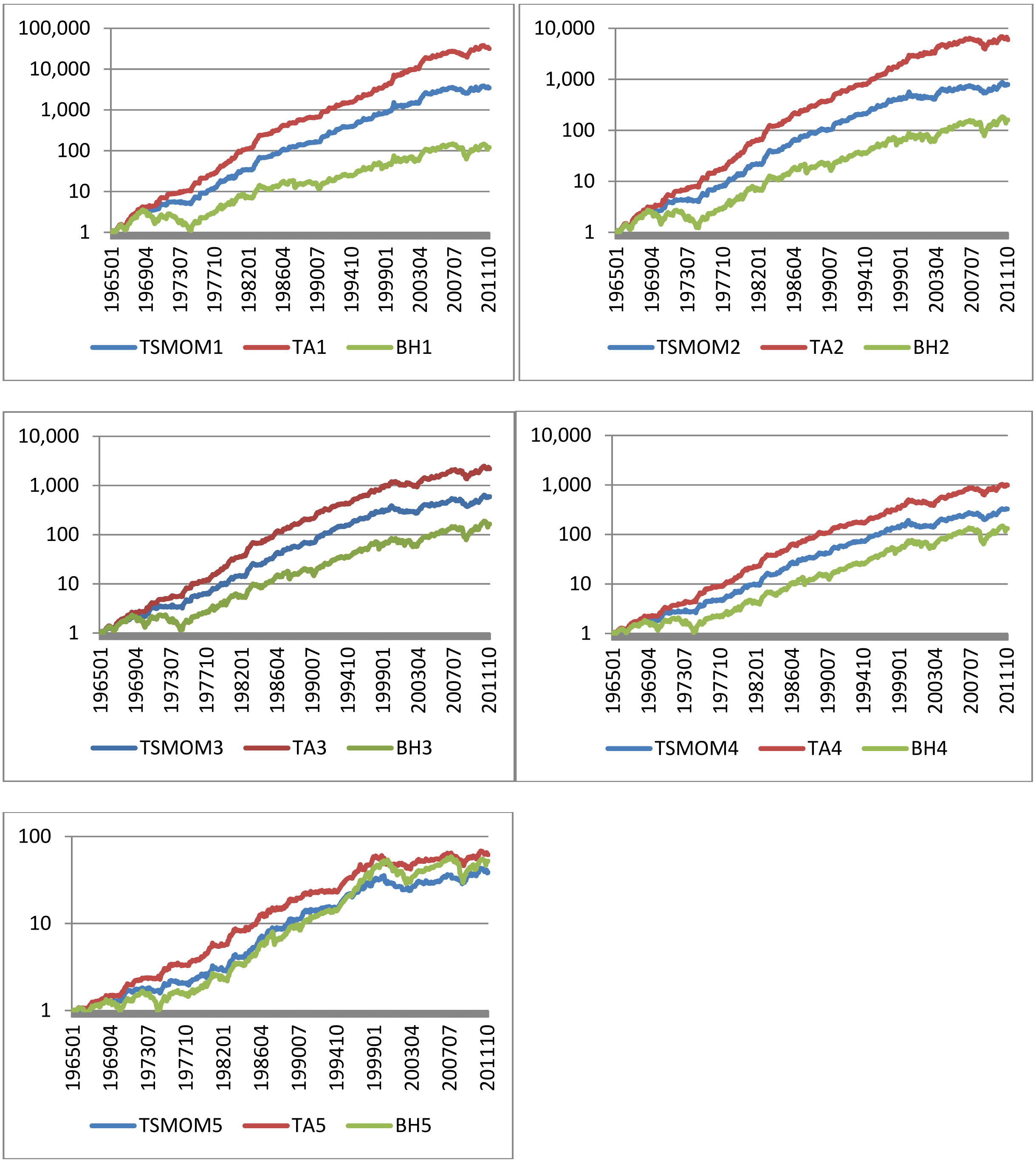


Figure 2
Time-Series Momentum and Technical Analysis Performance Versus Buy-and-Hold



These graphs show the performance of long-only trading rules with a 50-day look-back period, versus buy-and-hold performance (BH) for each portfolio. The first graph (1) is for the smallest portfolio and the last graph (5) is for the largest portfolio.

Appendix 1
Combining Time-Series Momentum and Technical Analysis

	Q1 (Small)	Q2	Q3	Q4	Q5 (Large)
Panel A: Holding Periods					
10	9	8	8	8	7
50	28	23	23	21	16
100	43	36	34	28	24
200	66	48	47	49	46
Panel B: Mean Returns					
10	2.23	1.81	1.60	1.47	0.67
50	1.70	1.39	1.29	1.16	0.73
100	1.46	1.23	1.23	1.11	0.77
200	1.17	1.04	1.05	1.06	0.82
Panel C: Sharpe Ratios					
10	0.45	0.38	0.35	0.34	0.09
50	0.33	0.26	0.26	0.23	0.11
100	0.26	0.21	0.23	0.20	0.12
200	0.18	0.15	0.17	0.19	0.12
Panel D: Jensen's Alphas					
10	1.46***	1.12***	0.93***	0.83***	0.10
50	0.90***	0.65***	0.57***	0.46***	0.14
100	0.57***	0.40***	0.45***	0.34***	0.11
200	0.17	0.09	0.14	0.21**	0.06

The results are as per Table 2, except that buy and sell signals are only implemented when both TA and TSMOM rules are in agreement. Statistical significance at the 10%, 5%, and 1% level (based on Newey and West (1987) standard errors) are denoted by *, **, and *** respectively.

Appendix 2
Long / Short Time-Series Momentum and Technical Analysis Robustness

	Q1 (Small)		Q2		Q3		Q4		Q5 (Large)	
	TA	TSMOM	TA	TSMOM	TA	TSMOM	TA	TSMOM	TA	TSMOM
Panel A: Holding Periods										
10	9	10	8	9	8	9	8	9	7	8
50	28	32	25	25	22	25	20	24	16	18
100	41	46	33	37	28	38	29	32	24	27
200	61	83	47	81	40	82	46	67	43	65
Panel B: Mean Returns										
10	3.38	2.69	2.61	1.92	2.38	1.45	1.98	1.18	0.56	-0.08
50	2.51	1.73	1.87	1.15	1.51	1.04	1.24	0.86	0.39	0.25
100	1.81	1.19	1.28	0.73	1.09	0.91	0.93	0.78	0.42	0.45
200	1.35	0.84	0.94	0.65	0.86	0.82	0.95	0.69	0.63	0.53
Panel C: Volatility										
10	5.46	5.36	5.32	5.36	4.71	4.95	4.53	4.61	4.09	4.13
50	5.40	5.63	5.51	5.46	5.09	5.02	4.65	4.70	4.13	4.41
100	5.68	5.79	5.56	5.60	5.22	5.04	4.96	4.90	4.17	4.46
200	5.92	6.23	5.75	5.94	5.20	5.48	4.66	5.27	4.36	4.81
Panel D: Sharpe Ratios										
10	0.54	0.42	0.41	0.28	0.42	0.21	0.34	0.16	0.03	-0.13
50	0.38	0.23	0.26	0.13	0.21	0.12	0.17	0.09	-0.01	-0.04
100	0.24	0.13	0.15	0.05	0.13	0.09	0.10	0.07	-0.00	0.00
200	0.15	0.06	0.09	0.04	0.08	0.07	0.11	0.05	0.04	0.02
Panel E: Jensen's Alphas										
10	3.07***	2.35***	2.32***	1.65***	2.09***	1.15***	1.65***	0.81***	0.16	-0.53**
50	2.18***	1.16***	1.53***	0.65**	1.08***	0.51**	0.80***	0.29	-0.08	-0.29
100	1.29***	0.42	0.75***	0.01	0.61***	0.17	0.41*	-0.01	-0.17	-0.26
200	0.52**	-0.25	0.16	-0.43	0.06	-0.23	0.19	-0.31	-0.15	-0.38
Panel F: Jensen's Alpha Difference p-value										
10	0.03		0.04		0.00		0.00		0.01	
50	0.00		0.01		0.07		0.08		0.42	
100	0.01		0.03		0.16		0.16		0.73	
200	0.02		0.07		0.34		0.09		0.39	

The results are as per Table 2, except that short equity market positions are entered following sell signals. Statistical significance at the 10%, 5%, and 1% level (based on Newey and West (1987) standard errors) are denoted by *, **, and *** respectively.

Appendix 3
Breakeven Transaction Costs

	Q1 (Small)	Q2	Q3	Q4	Q5 (Large)
			Panel A: TSMOM		
10	96	72	60	51	19
50	227	145	138	120	55
100	261	170	191	151	97
200	385	348	388	289	227
			Panel B: TA		
10	95	74	69	58	26
50	248	186	148	116	57
100	298	199	157	147	84
200	367	237	197	233	167

Appendix 3 contains estimates of the one-way transaction costs (in basis points) that would remove the profits to the TSMOM and TA rules.

Appendix 4
50-Day Look-Back Period and Ten-Day Minimum Holding Periods

	Q1 (Small)		Q2		Q3		Q4		Q5 (Large)	
	TA	TSMOM	TA	TSMOM	TA	TSMOM	TA	TSMOM	TA	TSMOM
Correlations	0.90		0.90		0.87		0.89		0.85	
Mean Returns	1.72	1.28	1.49	1.14	1.20	1.15	1.07	0.98	0.75	0.70
Volatility	4.57	4.82	4.26	4.22	4.13	3.96	3.88	3.74	3.38	3.40
Sharpe Ratio	0.28	0.18	0.25	0.17	0.19	0.18	0.16	0.15	0.09	0.08
Jensen's Alpha	0.81***	0.25*	0.66***	0.25**	0.42***	0.31***	0.31***	0.19*	0.11	0.01
Alpha Difference p-value	0.00		0.01		0.48		0.46		0.48	

The results are as per Table 2, except that long equity market positions are held for a minimum of ten days regardless of whether there is a sell signal during this time or not. If there is still a buy signal after the ten day period the position is maintained. Statistical significance at the 10%, 5%, and 1% level (based on Newey and West (1987) standard errors) are denoted by *, **, and *** respectively.