Long-Term Time Series Reversal: International Evidence

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Abstract

This paper is the first to examine the predictability of equity returns from extreme long-term past performances using a time-series approach. It builds on findings on the short-term 'time-series momentum' effect. The analysis is done at the individual time-series level as well as at the portfolio level. Average returns following extreme low long-term performances significantly exceed those following extreme high long-term performances for approximately half of the MSCI developed country indices, and for the country-average. Strategies exploiting the long-term 'time-series reversal' (TSR) effect provide superior risk-adjusted returns.

JEL Classifications: G11; G12; G15

Keywords: *Return reversal; asset pricing; trading strategies; time-series momentum*

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1. Introduction

The predictability of equity returns based on past returns continues to provide a challenge to the traditional asset pricing literature. Simply buying and selling equity securities based on their past performances can earn excess returns that the standard risk benchmarks cannot explain, as seen in the application of cross-sectional momentum and value strategies.

This study provides evidence on the predictive power of long-term past performance for expected returns by solely considering the individual security's own past performance, independent of its peers. We document a long-term time-series reversal (TSR) effect for the first two years following extreme long-term returns for developed market equity indices. This TSR effect is evident across approximately half the Morgan Stanley Capital International (MSCI) developed market equity indices and in the country-average, with the US and Japan market indices being notable exceptions. A contrarian strategy of buying long (selling short) those indices with low (high) recent long-term performances generates anomalous risk-adjusted returns.

The standard approach for predicting future returns from past returns uses a cross-sectional ranking during the formation. Sorting securities based on their *relative* short-term and long-term past returns within a cross-section provides evidence of the momentum and reversal effects. Momentum strategies show the tendency of relative short-term winners to continue to outperform relative short-term losers (Jegadeesh & Titman, 1993, 2001). Ample evidence confirms the robustness of momentum profits across time, countries, industry portfolios and diverse asset classes (see, for example, Asness, Moskowitz, and Pedersen, 2013). The persistent profitability of simple strategies exploiting short-term momentum has been widely accepted, along with the susceptibility of cross-sectional momentum strategies to large downwards risk following market declines and high market volatility (e.g., Barroso & Santa-Clara, 2015; K. Daniel & Moskowitz, 2016).

On the other hand, DeBondt and Thaler (1985, 1987) document the outperformance of past long-term losers relative to long-term winners in equity securities. Their evidence of a cross-sectional long-term reversal effect uses relative returns over 3-5 year formation periods to classify securities as losers or winners[1]. This cross-sectional reversal effect is evident across individual stocks, country indices, currencies, fixed income and commodities (e.g., Asness et al., 2013, and Fama & French, 1996).

In contrast, our time-series approach to reversal is related to recent research on time-series momentum (TSMOM). The time-series momentum trading signal involves buying or selling an asset solely based on the sign of that asset's *own* short-term past excess return, and has been labelled time-series momentum by Moskowitz, Ooi, and Pedersen (2012), absolute momentum by Antonacci (2014) and trend momentum by Berghorn (2015). Moskowitz et al. (2012), Antonacci (2014), He and Li (2015), and Goyal and Jegadeesh (2018) present evidence of anomalous short-term excess returns resulting from time-series momentum across numerous markets and asset classes. According to Antonacci (2014), TSMOM strategies tend to perform well in extreme market states and tend to limit the left-tail downside risk (as measured by maximum drawdown) that cross-sectional momentum strategies are prone to.

In their studies of time-series momentum, Moskowitz et al. (2012) and He and Li (2015) also note partial reversal of time-series momentum beyond a 12 months horizon. In contrast, following the approach by Moskowitz et al. (2012), Goyal and Jegadeesh (2018) do not confirm a significant long-term time-series reversal pattern in trading strategies based on individual US stocks. Our study addresses this inconsistency at the stock level in the recent literature with a comprehensive investigation into the existence of a long-term time-series reversal effect in developed market equity indices. Previous cross-sectional evidence of long-term reversal using

[1] In contrast, Bornholt, Gharaibeh, & Malin (2015) find that extreme 8-12 year industry returns tend to reverse.

international equity market indices has been reported by Richards (1997), Balvers and Wu (2006), and Malin and Bornholt (2013).

Our time-series approach differs from the time-series momentum approach of Moskowitz et al. (2012) in a number of important ways. Firstly, our approach allows us to investigate the presence of reversal in each security in the sample separately whereas the TSMOM approach only analyses the returns from a trading strategy that is based on the combining the signals from all of the securities. Secondly, the TSMOM trading strategy includes every security in the sample every month on either the long or the short side of the strategy whereas the TSR strategy each month only includes those securities with extreme past returns. We focus only on periods following extreme long-term returns because we seek to provide the time-series analogue to the contrarian cross-sectional method of DeBondt and Thaler (1985, 1987).[2]

In contrast to the contrarian cross-sectional approach, in the TSR strategy each long-term return is evaluated against that time series' own past performance history when determining long and short trading positions. As the long-term time-series reversal effect can be investigated for each individual market index, note that the TSR effect is related to, but significantly different from, the cross-sectional approach applied across the international equity markets. The aim of this paper is not to discriminate between arguments about market inefficiency, time-varying expected returns or the outperformance of a time-series based strategy over the traditional cross-sectional based strategy, nor to provide an explanation for the cause of the TSR effect. Rather, we empirically investigate the TSR effect's existence, persistence and profitability in international market indices.

[2] In addition, while the zero past excess return benchmark used in the TSMOM approach may be reasonable for classifying short-term returns, this benchmark seems increasingly problematic when classifying long-term returns because equity markets have positive expected returns.

We employ a sample of eighteen international MSCI developed country equity indices to examine long-term reversal at both the individual country level and across countries. Our approach allows us to identify the specific countries which show evidence of long-term return reversal. We find significant positive differences in annual returns following extreme low and high long-term returns for a subset of equity market indices. For example, in one case the Canadian index produces a significant return difference of 22.9% whereas the corresponding difference for the US index is an insignificant difference of 4.1%. The effect is strong enough to be observed in the country-average. For example, across all 18 countries the average first year return following a low 60-month return exceeds the average first year return following a high 60-month return by a highly significant 16.67%.

We also examine investable TSR-based contrarian trading strategies which take a long (short) position in a stock index if its most-recent long-term return is an extreme low (high). The study documents positive risk-adjusted strategy results and significant alphas. We also find that the long-term TSR effect provides the potential to limit downside risk exposure when used in market timing strategies.

In summary, this paper provides strong evidence that approximately half of the international equity market indices in our study show long-term TSR effects. The robust findings across various formation and holding periods imply that the effect is not spurious nor a result of data-mining. Investors can exploit the long-run TSR effect in an active trading strategy to generate superior returns. The persistence of abnormal returns cannot be explained by standard risk benchmarks, such as global market risk exposure. Similar to the time-series momentum effect, we find that the TSR strategies exhibit reduced drawdown risk.

These findings contribute to the current literature on time-series predictability with empirical insights into the market return dynamics of international markets. Since this paper extends the understanding of time-series properties in the existing literature beyond the short-

term horizon used in time-series momentum studies, the results may assist investment managers to enhance fund performances across countries while controlling downside risk exposure. Specifically, these findings are relevant to the allocation and investment decision-making processes of institutional and individual investors.

The rest of the paper is organized as follows. Section 2 outlines the data. Section 3 describes the methodology used to examine the long-term TSR effect and the trading strategies evaluating TSR profitability. Section 4 reports the empirical evidence of long-term time-series reversal and its profitability. Section 5 concludes and summarizes the key findings.

2. Data

The monthly total returns for 18 MSCI developed market equity indices denoted in US dollar terms are obtained from *Datastream*. The sample contains 555 monthly returns spanning a period of 46 years and 3 months between January 1970 and March 2016. The monthly index returns for each country are based on reinvested gross dividends converted into US dollars.

To evaluate the strategy results with standard asset pricing benchmarks, data for the MSCI value (*V*) and growth (*G*) style indices as well as for the MSCI World Index are downloaded from Datastream. The Fama-French size (*SMB*) and book-to-market value (*HML*) factors, together with the monthly US Treasury bill yield and the Centre of Research in Security Prices (CRSP) value-weighted market index (*VW*) of all US stocks are retrieved from the Kenneth French website[3]. Table 1 reports summary statistics for each equity index and the US Treasury bill.

[3] See http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html.

Table 1 Summary Statistics

	Countries	Average monthly return (in %)	Standard Deviation (in %)	Skewness	Excess Kurtosis
1	Australia	0.95	6.97	-0.63	4.26
2	Austria	0.84	6.81	-0.19	4.06
3	Belgium	1.10	5.90	-0.52	5.06
4	Canada	0.90	5.68	-0.48	2.23
5	Denmark	1.21	5.65	-0.14	1.79
6	France	0.99	6.49	-0.11	1.29
7	Germany	0.97	6.35	-0.31	1.32
8	Hong Kong	1.61	9.91	0.93	11.85
9	Italy	0.68	7.39	0.15	0.70
10	Japan	0.91	6.09	0.23	0.78
11	Netherlands	1.10	5.56	-0.46	2.15
12	Norway	1.12	7.87	-0.32	1.46
13	Singapore	1.18	8.15	0.40	5.77
14	Spain	0.91	6.80	-0.11	1.51
15	Sweden	1.27	6.92	-0.13	1.05
16	Switzerland	1.03	5.25	-0.13	1.28
17	UK	0.96	6.30	1.18	11.36
18	US	0.89	4.42	-0.40	1.82
	Average	**1.03**	**4.78**	**-0.74**	**3.11**
	World	**0.84**	**4.29**	**-0.53**	**1.60**
	R_f	**0.51**	**0.28**	**0.52**	**0.41**

Reported are the averages and standard deviations of monthly returns from January 1970 to March 2016 across the 18 MSCI developed markets, as well as the skewness and excess kurtosis. Average is the equally weighted average index across all country indices, World denotes the MSCI World Index, and R_f denotes the one-month US Treasury bill.

3. Methodology

This study tests for a *time-series* long-term return reversal effect in the individual time-series of each country index, and across countries. This section presents the following: (i) the definition of the long-term time-series reversal effect, (ii) the methods used to identify reversal patterns within country indices, and (iii) the risk-adjustment procedures. Our study has two distinct parts. We first investigate whether or not there is evidence of a time-series reversal effect in the individual country indices, and the implications of any such effect for country-averages and for cross-sectional studies. This is followed by an analysis of the results from

trading strategies designed to exploit any such reversal. The following two subsections describe the methodology employed in the study.

3.1. Time-series reversal

In contrast to the cross-sectional approach where stocks are classified into the extreme past losers and past winners' portfolios based on their recent 3-5 years performances relative to their peers (DeBondt and Thaler, 1985, 1987), the univariate time-series reversal approach examines the asset's return dynamics based on its own prior extreme low and high long-term past returns. We investigate whether past extreme long-term performances tend to reverse.

To classify an asset's past performance, we employ *J*-month formation periods for $J = 48$, 60 and 72 months. Common to the cross-sectional literature, the formation lengths are centered at five years (Asness et al., 2013). Thus, the $J = 60$ months case is our base case, while the other lengths provide evidence of robustness. At the end of each month *t*, its most-recent *J*-month compound return is classified as low (*LO*) or high (*HI*), based on the extremes of the entire sample of rolling *J*-month returns for that country index. Different to the excess return benchmark in the time-series momentum approach, our trading signal focuses on the extreme performances. The entire sample produces 508 rolling 48-month, 496 rolling 60-month and 484 rolling 72-month formation periods. An index's *J*-month returns are classified as *LO* if they are amongst the lowest 25% of all the *J*-month returns for that asset in the sample. Similarly, its *J*-month returns are classified as *HI* if they are amongst the highest 25% of all the *J*-month returns for that asset in the sample[4]. To investigate possible reversal patterns, we record average annual returns for the first five years following the *LO* and the *HI* returns.

[4] Some analysis was undertaken using 20% and 30% benchmarks. These produced qualitatively similar results.

Let *y* denote the years post-formation (*y* = 1, 2, …, 5) and *i* denote the respective country, (*i* = 1, 2, …, 18), while the absence of *i* denotes the equally weighted country-average return. The annual average returns following the *LO* and *HI* returns are denoted as $R_{yi|LO}$ and $R_{yi|HI}$, respectively. If TSR is present, we expect significantly higher annual returns following *LO* returns than following *HI* returns. Thus, our focus is on the significance of positive return differences ($R_{yi|LO} - R_{yi|HI}$) as evidence of the long-term TSR effect. Note that, by construction, the expected value of the $R_{yi|LO} - R_{yi|HI}$ difference is slightly positive under the null hypothesis of independent monthly returns[5]. For risk considerations, we also report the corresponding annual Sharpe ratios and respective Sharpe ratio differences, $S_{yi|LO}$, $S_{yi|HI}$, $S_{yi|LO} - S_{yi|HI}$. The Sharpe ratios allow us to test whether observed significance in raw returns could have a simple risk-based explanation, e.g., higher volatility of returns following *LO* versus *HI* periods.

We employ the Fisher randomization test procedure, which is based on the null hypothesis assumption of independently distributed returns. This procedure provides exact small sample *p*-values, and is similar to the bootstrap technique except that the random sampling is without replacement[6]. In particular, it accommodates the dependency in overlapping returns and automatically adjusts for the slightly positive mean return difference under the null hypothesis. We employ 10,000 permutations in the randomization tests.

3.2. Construction of TSR based strategies and regression analysis

In this section, we describe the construction of TSR strategies to investigate the profitability of the long-term TSR effect, and the methods of risk-adjustment of portfolio

[5] Since *HI* (*LO*) formation periods cover many of the larger (smaller) returns, the remaining subset of the sample tends to comprise somewhat lower (higher) annual expected returns than the unconditional expected return.

[6] See Noreen (1989) for further details of Fisher randomization methods.

returns. The strategy is based on a contrarian signal applied each month *t* to each country index *i* for *i* = 1, 2, …, 18. For robustness, we examine TSR trading strategies across various formation and holding periods.

As in the previous section, *J* is used to define the length of the formation period specific to the trading signal (*J* = 48, 60, 72), while *K* refers to the *K*-month holding periods (*K* = 1, 3, 6, 9, 12, 24, 26, 48, 60) following the formation period. All (*J*, *K*) pairs provide 27 possible contrarian strategies. If a country's recent *J*-month return is identified as low (high) then the country is included long (short) in the strategy for that month. In contrast to the previous ex-post definition of the *LO* and *HI*, for the trading strategies we use ex-ante benchmarks. We do this by determining the *LO* or *HI* classification of a country's recent *J*-month return by using *J*-month thresholds derived from *pre-1970* US data.

Specifically, we employ the CRSP US value-weighted market index (*VW*) monthly returns from 1926 to December 1969 to produce the thresholds. In this period, 25% of the *VW*'s 48-month, 60-month and 72-month rolling formation returns did not exceed the VW_{LO} benchmarks of 23.5%, 39.6% and 58.1%, respectively. Similarly, 25% of the *VW*'s 48-month, 60-month and 72-month periods achieved returns greater than the VW_{HI} thresholds of 85.0%, 109.9% and 125.1%, respectively. These *VW* thresholds are applied to each country. Specifically, if a country's current *J*-month formation return is below (above) the corresponding VW_{LO} (VW_{HI}) threshold, then the country's *J*-month return is defined as *LO* (*HI*) and the TSR signal initiates a long (short) position in the particular country index. If the *J*-month return for a country index does not classify as either *LO* or *HI*, then that country does not participate in the TSR(*J*,*K*= 1) strategy for that month.

The TSR(*J*,*K*= *1*) contrarian strategy return in each month *t*, denoted by $R_t^{TSR(J,K=1)}$, is the equally weighted average return over a one-month holding period from all of the long/short positions of the participating countries (those with extreme returns in the most-recent past *J*-

month period). To strengthen our results, we employ portfolios with *K*-month overlapping holding periods using the overlapping portfolio approach of Jegadeesh and Titman (1993, 2001). This method tends to reduce the risk of receiving spurious results based on lead-lag effects, reduces transaction costs, and allows the use of simple *t*-statistics by avoiding overlapping returns (Lee & Swaminathan, 2000).

To test whether TSR-based trading strategies generate positive abnormal returns, we compute the alphas of the following two regression models:

$$r_t^{TSR(J,K)} = \alpha + \beta r_{MSCI,t} + hVmG_t + \varepsilon_t \quad (1)$$

$$r_t^{TSR(J,K)} = \alpha + \beta r_{MSCI,t} + sSMB_t + hHML_t + \varepsilon_t \quad (2)$$

where $r_t^{TSR(J,K)}$ denotes the TSR (*J*,*K*) strategy excess returns determined by subtracting the US Treasury bill rate from $R_t^{TSR(J,K)}$. The independent variables are as follows: $r_{MSCI,t}$ is the excess return on the MSCI World Index; VmG_t is the MSCI value factor premium calculated as the return on the MSCI value index minus the return on the MSCI growth index; while SMB_t and HML_t are the Fama-French US size and value factor returns. Similar to prior studies, these models are used to determine whether TSR strategy returns are driven by passive market exposures or by well-known anomalies such as the size or value effects (Balvers & Wu, 2006; Marshall, Nguyen, & Visaltanachoti, 2014; Moskowitz et al., 2012). An economically and financially significant alpha would show that these risk-based regression models are unable to explain the monthly returns of the TSR-based strategy. Note that the TSR strategies have time-varying market exposure, by construction.

4. Results and Discussion

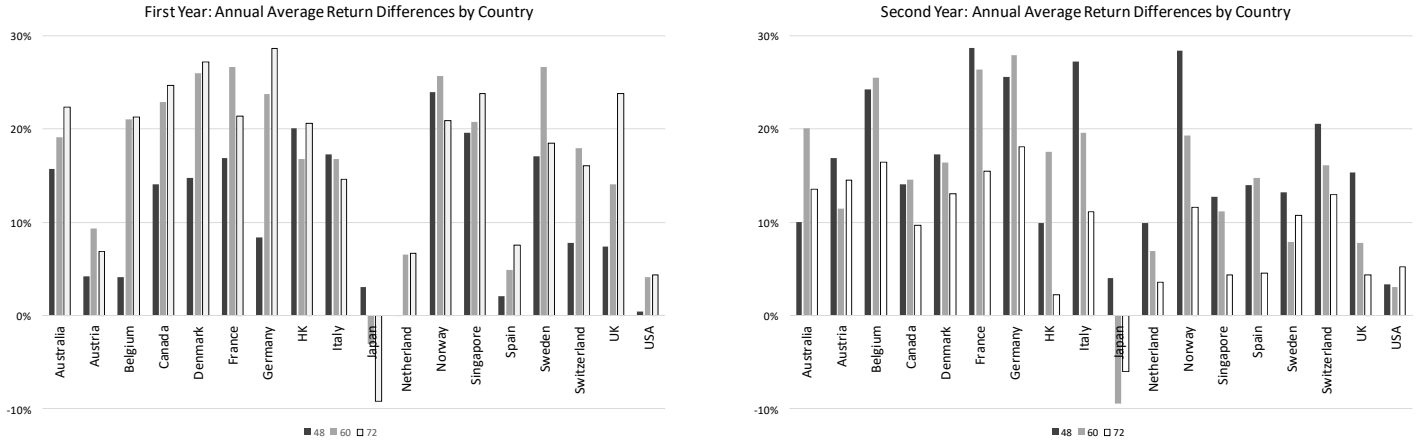
4.1. Individual time-series reversal

Figure 1 reports each country's average return and Sharpe ratio differences for the first two years following extreme past performances. The consistent positive return differences across the country indices, $R_{yi|LO} - R_{yi|HI}$, provide an initial indication of the prevailing reversal patterns in developed equity markets with a one month holding period (K = 1). As the first two years of the base case (J = 60) are the most profitable overall, the figures in *Panels A* and *B* focus on years one and two across the three ranking periods (J = 48, 60, 72). Remarkably, all countries indicate positive annual average return differences post-formation, with the exception of Japan for J = 60 and 72 for years one and two and the Netherlands for J = 48 for year one only. The formation period is crucial for the magnitude and distribution of return differences through time. Similar patterns are observed regarding the Sharpe ratio differences, $S_{yi|LO} - S_{yi|HI}$.

Table 2 reports the average annual returns differences ($R_{yi|LO} - R_{yi|HI}$) and significance levels for the first four years post-formation for J = 48, 60, 72 months and for each country index[7]. Across the three formation periods, eleven countries exhibit positive average differences that are significant at the 5% level in at least Year 1 or Year 2. For example, Belgium with J = 60 has significantly higher returns following *LO* returns than those subsequent to *HI* returns, with positive differences of 21.04% and 25.52% in the first and second years, respectively. In contrast, the Hong Kong, Japan, Netherlands, Singapore and the US indices do not produce significant average return differences for any J period.

[7] As indicated in the methodology, five years post-formation were investigated. Results for the fifth year are available on request.

Panel A



Panel B

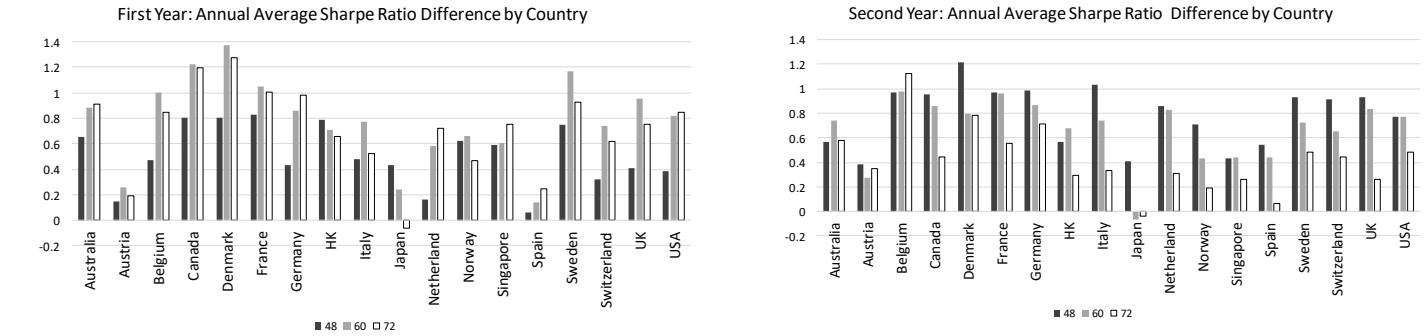


Figure 1 Return differences and Sharpe ratio differences by developed country
Panel A depicts the *annual average return* differences, $R_{yi|LO} - R_{yi|HI}$, for the first and second year following the end of the formation period for the 18 developed countries. *Panel B* reports the *annual average Sharpe ratio* differences, $S_{yi|LO} - S_{yi|HI}$, for the first year and second year following the end of the formation periods for the 18 developed countries. The formation period varies in length (J = 48, 60, and 72 months).

Overall, the results show that the time-series reversal for formation periods of J = 48 months is strongest in the second year, with seven countries displaying significant differences at 5%; while for the J = 60 and 72 cases, they are strongest in the first year with eight countries and seven countries, respectively, having significant differences. Note that the largest number of significant results with 5% level of significance are found in the J = 60 months base case over the first two years post-formation. In short, Table 2 indicates that approximately half of

the 18 MSCI developed market indices have significant long-term reversal evident in the relevant return differences.

Regarding evidence of long-term reversal in the MSCI World Index, the final row of Table 2 reports a single significant return difference (12.53% for Year 2 in the $J = 48$ case). None of the World Index return differences for the $J = 60$ and 72 cases are significant at the 5% level, even though eight countries for $J = 60$ and seven countries for $J = 72$ have significant return differences for Year 1. Overall, the evidence of return reversal in the World index is weaker than it is in some of the country indices. We can see that country-level reversal information is not simply replicated in the World index.

To analyze the TSR reversal patterns in more detail, Table 3 presents a breakdown of the average annual returns and Sharpe ratios of the first two years following the *LO* and the *HI* returns separately. The results are for the $J = 60$ base case. Table 3 reports five (eight) out of 18 countries exhibit significant average returns following the *LO* returns at the 5% level in year one (year two), whereas only four (two) countries show significant reversal following *HI* returns in year one (year two). Overall, significant evidence of reversal following *LO* returns occurs for more countries than does significant evidence of reversal following *HI* returns.

To see whether the evidence of reversal could have a simple risk-based explanation, consider the Sharpe ratio results in the table. Table 3 reports nine (seven) out of 18 countries exhibit significant Sharpe ratios following the *LO* returns at the 5% level in year one (year two), whereas only four (two) countries produce significant Sharpe ratios following *HI* returns in year one (year two). In general, the returns subsequent to *LO* periods tend to exhibit stronger evidence of reversal than do the returns following *HI* periods. Comparing the Sharpe ratio results in Table 3 with the average return results suggests that the risk-adjusted results subsequent to *LO* performances tend to be stronger than the corresponding unadjusted results. Considering the Sharpe ratio differences for the 18 country indices, nine are significant at the

5% level for year one and six are significant for year two. As with the unadjusted results, the risk-adjusted results indicate that approximately half of the 18 country indices exhibit long-term return reversal.

Interestingly, although the UK and US return differences are not statistically significant, their respective Sharpe ratio differences are significant at either the 5% or 10% level. Moreover, for both of these countries, their Sharpe ratios following *LO* returns show very strong evidence of return reversal, with significance at the 1% level in year one and at the 1% or 5% level for year two.

Given the importance of the US equity market, we next investigate the robustness of the TSR evidence for the US equity market using a longer data set: the CRSP value-weighted market index of all US stocks (VW) from July 1926 to March 2016. The VW data for the whole sample period is denoted VW1926, while the VW sub-period from January 1970 to March 2016 (which matches the MSCI data period) is denoted VW1970.

The VW1970 evidence presented in Table 4 is largely consistent with the MSCI US evidence previously reported in Table 3, the exception being that the Sharpe ratio differences in the final column are significant at the 5% level for VW1970 but not for MSCI US. In general, none of the US annual return differences in Table 4 are significant at the 5% level. Interestingly, the longer VW1926 sample produces a significant average return of 18.14% in the second year following *LO* returns, much larger than the corresponding values of 12.25% and 13.85% for the more recent MSCI US and VW1970 datasets, respectively. The only consistent significance across the three US samples is that all the Sharpe ratios for Year 2 following *LO* returns are large and significant. This evidence suggests that US market index returns in the second year following *LO* returns have abnormally low volatility.

Table 2: Reversal in developed market indices: Country results across formation periods

Formation	48				60				72			
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 1**	**Year 2**	**Year 3**	**Year 4**
Australia	0.1574	0.0999	0.1157	0.1043	0.1913*	0.2005*	0.0876	-0.0002	0.2236**	0.1355	0.0469	0.0488
Austria	0.0424	0.1686*	0.1576*	0.1572*	0.0932	0.1149	0.1516	0.1256	0.0686	0.1448	0.1930*	0.2629**
Belgium	0.0408	0.2427***	0.2388***	0.2026**	0.2104**	0.2552***	0.1300	0.2157**	0.2126**	0.1647*	0.1075	0.1617*
Canada	0.1412*	0.1410*	0.1201	-0.0019	0.2294**	0.1454*	0.0186	-0.0908	0.2470***	0.0963	-0.0214	0.0296
Denmark	0.1479*	0.1726**	0.1428*	0.1389*	0.2601***	0.1642*	0.1203	0.0401	0.2724***	0.1310	0.0558	0.1246
France	0.1693*	0.2873***	0.1710*	0.0238*	0.2671***	0.2640***	0.0163	-0.1049	0.2142**	0.1547	-0.0426	-0.0767
Germany	0.0833	0.2559***	0.2063**	0.1499*	0.2377**	0.2796***	0.1730*	0.0473	0.2868***	0.1813*	0.0151	0.0966
HK	0.2012	0.0994	0.1740	-0.0672	0.1678	0.1756	0.0455	-0.1825	0.2062	0.0218	-0.1222	-0.1170
Italy	0.1730	0.2721***	0.1445	-0.0032	0.1676	0.1956*	0.0540	-0.0373	0.1462	0.1115	-0.0164	0.0826
Japan	0.0301	0.0397	-0.0687	-0.1358	-0.0306	-0.0940	-0.1095	-0.1103	-0.0917	-0.0597	-0.0655	-0.0088
Netherlands	-0.0002	0.0990	0.0845	0.0595	0.0649	0.0692	0.0113	0.0529	0.0670	0.0359	-0.0174	0.0151
Norway	0.2397**	0.2846**	0.0595	-0.0706	0.2570**	0.1928	0.0116	-0.0405	0.2093	0.1159	0.0286	0.1026
Singapore	0.1963	0.1277	0.0635	0.0381	0.2076	0.1119	0.0048	-0.0563	0.2386*	0.0437	-0.0300	0.0923
Spain	0.0212	0.1402	0.2208**	0.1767*	0.0492	0.1473	0.1480	0.2152	0.0756	0.0456	0.1833*	0.2678**
Sweden	0.1713	0.1318	0.0302	0.1292	0.2669**	0.0791	0.0002	0.0668	0.1851	0.1072	0.0169	0.1679
Switzerland	0.0777	0.2061***	0.1390*	0.1126	0.1799**	0.1607**	0.1313*	0.0160	0.1610*	0.1299	0.0042	0.0474
UK	0.0738	0.1534*	0.1067	0.0594	0.1403	0.0774	0.0602	-0.0586	0.2386**	0.0437	-0.0300	0.0923
US	0.0039	0.0331	0.0401	0.0207	0.0412	0.0303	0.0139	0.0132	0.0438	0.0525	0.0063	0.0329
World	0.0474	0.1253**	0.0934	0.0366	0.1076	0.1045*	0.0587	0.0021	0.0969	0.0778	-0.0068	-0.0105

Reported are the country-specific *average annual returns differences* ($R_{yi|LO} - R_{yi|HI}$) following past *LO* or *HI* formation periods for four years post-formation, along with the corresponding results for the MSCI World Index. The 48-, 60- and 72-month formation period cases are presented.

Note: *, **, *** denote significance at the 10%, 5%, and 1% levels, respectively.

Table 3: Breakdown of annual return and Sharpe ratio differences by country

	Average $(R_{yi\|LO})$		**Average** $(R_{yi\|HI})$		**Average** $(R_{yi\|LO} - R_{yi\|HI})$		**Sharpe Ratio** $(S_{yi\|LO})$		**Sharpe Ratio** $(S_{yi\|HI})$		**Sharpe Ratio** $(S_{yi\|LO} - S_{yi\|HI})$	
	Year 1	**Year 2**	**Year 1**	**Year 2**	**Year 1**	**Year 2**	**Year 1**	**Year 2**	**Year 1**	**Year 2**	**Year 1**	**Year 2**
Australia	0.2436*	0.2507**	0.0523	0.0502	0.1913*	0.2005*	0.8408**	0.7149*	-0.0448	-0.0237	0.8855**	0.7386*
Austria	0.2066*	0.2298**	0.1135	0.1149	0.0932	0.1149	0.3895	0.4177	0.1349	0.1468	0.2546	0.2709
Belgium	0.2703**	0.2819**	0.0599	0.0267**	0.2104**	0.2552***	1.0249**	0.9016*	0.0251	-0.0752**	0.9999**	0.9768**
Canada	0.2049*	0.2238**	-0.0245***	0.0784	0.2294**	0.1454*	0.8298**	0.9231**	-0.3893***	0.0672	1.2191**	0.8559*
Denmark	0.2518*	0.2329	-0.0082***	0.0688*	0.2601***	0.1642*	1.0981**	0.9111*	-0.2733***	0.1154*	1.3714***	0.7957**
France	0.3049***	0.2892**	0.0378	0.0252*	0.2671***	0.2640***	0.9695***	0.8497**	-0.0800	-0.1116*	1.0495**	0.9613**
Germany	0.2631**	0.3203***	0.0254*	0.0407	0.2377**	0.2796***	0.7343*	0.8033**	-0.1223*	-0.0622	0.8566**	0.8655**
HK	0.2923	0.2280	0.1245	0.0524*	0.1678	0.1756	0.8543**	0.6282	0.1487	-0.0519**	0.7056*	0.6801*
Italy	0.1078	0.1754	-0.0599**	-0.0202*	0.1676	0.1956*	0.2309	0.4029	-0.5421**	-0.3391*	0.7730*	0.7421*
Japan	0.1697	0.0721	0.2003	0.1662	-0.0306	-0.0940	0.5738	0.2343	0.3317	0.2985	0.2421	-0.0643
Netherlands	0.1728	0.1728	0.1078	0.1036	0.0649	0.0692	0.7780	1.0762**	0.1989	0.2474	0.5791	0.8287**
Norway	0.2965**	0.2803**	0.0395	0.0876	0.2570**	0.1928	0.6173	0.5367	-0.0475	0.1063	0.6648	0.4304
Singapore	0.2613	0.1424	0.0538	0.0305*	0.2076	0.1119	0.5471	0.3361	-0.0568	-0.1035*	0.6039	0.4396
Spain	0.1176	0.1455	0.0684	-0.0018**	0.0492	0.1473	0.1949	0.2205	0.0585	-0.2163*	0.1364	0.4368
Sweden	0.2868*	0.2640	0.0199**	0.1849	0.2669**	0.0791	1.0338**	1.0337**	-0.1347**	0.3115	1.1686***	0.7222*
Switzerland	0.2518**	0.2656***	0.0719	0.1050	0.1799**	0.1607**	0.8152	0.8735*	0.0740	0.2228	0.7412*	0.6507
UK	0.2294*	0.1706	0.0891	0.0932	0.1403	0.0774	1.0041***	0.9655***	0.0511	0.1286	0.9530**	0.8369**
US	0.1532	0.1225	0.1120	0.0923	0.0412	0.0303	1.1654***	0.9916**	0.3480	0.2178	0.8174*	0.7738*
World	**0.1729***	**0.1463**	0.0653	0.0419*	0.1076	0.1045*	1.3434***	1.5265***	0.0398	-0.0656*	1.3036***	1.592***

Reported for the first two years post-formation are the average annual returns ($R_{yi|LO}$, $R_{yi|HI}$), return differences ($R_{yi|LO} - R_{yi|HI}$), Sharpe Ratios ($S_{yi|LO}$, $S_{yi|HI}$), and Sharpe Ratio differences ($S_{yi|LO} - S_{yi|HI}$) for 18 countries and the World Index. The table is for the base case (J = 60). *Note:* *, **, *** denote significance at the 10%, 5%, and 1% levels, respectively.

Table 4: Breakdown of annual return and Sharpe ratio differences for US Indices

	Average $(R_{yi\|LO})$		Average $(R_{yi\|HI})$		Average $(R_{yi\|LO} - R_{yi\|HI})$		Sharpe Ratio $(S_{yi\|LO})$		Sharpe Ratio $(S_{yi\|HI})$		Sharpe Ratio $(S_{yi\|LO} - S_{yi\|HI})$	
Index	**Year 1**	**Year 2**	**Year 1**	**Year 2**	**Year 1**	**Year 2**	**Year 1**	**Year 2**	**Year 1**	**Year 2**	**Year 1**	**Year 2**
MSCI US	0.1532	0.1225	0.1120	0.0923	0.0412	0.0303	1.1654***	0.9916**	0.3480	0.2178	0.8174*	0.7738*
VW1970	0.1673	0.1385	0.0856	0.0927	0.0818	0.0458	1.2913***	1.2291***	0.1670	0.1828	1.1243**	1.0463**
VW1926	0.1713*	0.1814**	0.0817	0.1144	0.0896	0.0670	0.5844	0.7413**	0.3562	0.5678	0.2282	0.1734

Reported for the first two years post-formation are the average annual returns ($R_{yi|LO}$, $R_{yi|HI}$), return differences ($R_{yi|LO} - R_{yi|HI}$), Sharpe ratios ($S_{yi|LO}$, $S_{yi|HI}$), and Sharpe ratio differences ($S_{yi|LO} - S_{yi|HI}$) for various US indices and sample periods. MSCI US is the MSCI US monthly market index (returns from Jan 1970-March 2016) reported in Table 3 as US; VW is the CRSP value-weighted market index of all US stocks, VW1970 is based on monthly VW returns from Jan 1970-March 2016, and VW1926 is based on monthly returns from July 1926-March 2016. The table is for the base case (J = 60). *Note:* *, **, *** denote significance at the 10%, 5%, and 1% levels, respectively.

Given the presence of underlying reversal patterns in approximately half of the 18 country indices, the country-average results are also worth examining. Thus, Table 5 reports the country-average results ($R_{y|LO}$, $R_{y|HI}$, and $R_{y|LO} - R_{y|HI}$) across the 18 developed markets for the three formation periods, along with the associated Sharpe ratios. We see that the country-average return differences ($R_{y|LO} - R_{y|HI}$) are positive across almost all *J*-month formation periods and all five years of the post-ranking periods, the only exception being an insignificantly negative 3.24% return difference for Year 5 of the *J* = 48 case. For *J* = 48, Table 5 reports significant evidence of the TSR effect, with country-average return differences of 16.42% (*p*-value 0.006) and 11.92% (*p*-value 0.042) in the second and third years, respectively. The Sharpe ratio differences, $S_{y|LO} - S_{y|HI}$, in this case are all significant for the first three years post-formation.

Similarly, the *J* = 60 base case shows strong reversal evidence in the first two years for both the country-average and the corresponding Sharpe ratio differences, with the latter being significant at the 1% level. In the 72-month formation period case, the country-average results are only significant in the first year post-formation. Table 5 indicates that there is a sharp decline in the return differences after the third year for the *J* = 48 month case, after the second year for the *J* = 60 case, and after the first year for the 72-month case.

Overall, the *J* = 60 base case exhibits the strongest reversal effect. While the first year following *LO* returns achieves a highly significant average return of 22.69% (*p*-value 0.007) the first year following a *HI* return earns an average return of only 6.02% (*p*-value 0.042); this leads to a highly significant return difference of 16.67% (*p*-value 0.006). A similar pattern is observed for the second year, with a significant average return difference of 14.27% (*p*-value 0.020). In general, the significant return differences seem to be driven mostly by stronger reversal following low long-term performances in contrast to the reversals following high long-

term performances. The risk-adjusted evidence provided by the Sharpe ratios is generally as strong, if not stronger, than the evidence from the raw returns. In the J = 60 case, for example, the year one and year two Sharpe ratio differences are both significant at the 1% level, with differences of 0.7790 (p-value 0.001) and 0.6634 (p-value 0.008), respectively.

Table 5: Reversal in developed market indices: Country-average results

	Annual Returns						Sharpe Ratios				
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**		**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Formation		**48**									
$R_{y\|LO}$	0.1947	0.2265	0.2056	0.1635	0.1050	$S_{y\|LO}$	0.5997	0.7868	0.6102	0.3999	0.1675
(p)	(0.064)	(0.007)	(0.030)	(0.271)	(0.904)	(p)	(0.055)	(0.001)	(0.050)	(0.476)	(0.955)
$R_{y\|HI}$	0.0852	0.0623	0.0863	0.1027	0.1375	$S_{y\|HI}$	0.0915	0.0019	0.1131	0.2174	0.3781
(p)	(0.200)	(0.031)	(0.158)	(0.320)	(0.77)	(p)	(0.091)	(0.014)	(0.096)	(0.309)	(0.797)
$R_{y\|LO} - R_{y\|HI}$	0.1095	0.1642	0.1192	0.0608	-0.0324	$S_{y\|LO} - S_{y\|HI}$	0.5082	0.7849	0.4971	0.1826	-0.2106
(p)	(0.082)	(0.006)	(0.042)	(0.260)	(0.893)	(p)	(0.045)	(0.001)	(0.043)	(0.375)	(0.942)
Formation		**60**									
$R_{y\|LO}$	0.2269	0.2149	0.1667	0.1188	0.1545	$S_{y\|LO}$	0.7612	0.7123	0.4337	0.2182	0.3214
(p)	(0.007)	(0.021)	(0.276)	(0.827)	(0.393)	(p)	(0.002)	(0.008)	(0.416)	(0.932)	(0.737)
$R_{y\|HI}$	0.0602	0.0721	0.1073	0.1126	0.1297	$S_{y\|HI}$	-0.0178	0.0488	0.2048	0.2571	0.3753
(p)	(0.042)	(0.085)	(0.435)	(0.486)	(0.699)	(p)	(0.017)	(0.044)	(0.316)	(0.461)	(0.793)
$R_{y\|LO} - R_{y\|HI}$	0.1667	0.1427	0.0594	0.0062	0.0248	$S_{y\|LO} - S_{y\|HI}$	0.7790	0.6634	0.2289	-0.0388	-0.0539
(p)	(0.006)	(0.020)	(0.318)	(0.712)	(0.554)	(p)	(0.001)	(0.008)	(0.341)	(0.805)	(0.809)
Formation		**72**									
$R_{y\|LO}$	0.2287	0.1861	0.1322	0.1718	0.1605	$S_{y\|LO}$	0.7155	0.5654	0.2939	0.3778	0.3264
(p)	(0.011)	(0.168)	(0.757)	(0.261)	(0.370)	(p)	(0.011)	(0.135)	(0.846)	(0.614)	(0.742)
$R_{y\|HI}$	0.0618	0.0941	0.1149	0.0928	0.1466	$S_{y\|HI}$	0.0018	0.1412	0.2435	0.1979	0.4758
(p)	(0.068)	(0.319)	(0.556)	(0.253)	(0.853)	(p)	(0.032)	(0.208)	(0.470)	(0.310)	(0.948)
$R_{y\|LO} - R_{y\|HI}$	0.1669	0.0920	0.0173	0.0790	0.0139	$S_{y\|LO} - S_{y\|HI}$	0.7069	0.4242	0.0504	0.1799	-0.1495
(p)	(0.011)	(0.188)	(0.695)	(0.216)	(0.668)	(p)	(0.007)	(0.125)	(0.721)	(0.443)	(0.92)

Reported are the country-average annual returns and associated Sharpe ratios following past *LO* and *HI* formation period returns for five years post-formation. The *J*-month *HI (LO)* returns for a country index are those with *J*-month returns contained in the highest (lowest) of 25% *J*-month formation periods of that index's entire return series. The $\boldsymbol{R_{y|LO}}$ and $\boldsymbol{S_{y|LO}}$ refer to the country-average annual returns and Sharpe ratios following low performing periods. The $\boldsymbol{R_{y|HI}}$ and $\boldsymbol{S_{y|HI}}$ refer to the country-average annual returns and Sharpe ratios following high performing periods, while the $\boldsymbol{R_{y|LO} - R_{y|HI}}$ or the $\boldsymbol{S_{y|LO} - S_{y|HI}}$ describe the country-average annual return differences or the Sharpe ratio differences. The associated randomization *p*-values are provided in parentheses underneath each respective measure for each of the formation periods (J = 48, 60 and 72 months).

In summary, this first part of our study has found strong evidence of a persistent, long-run time-series reversal effect in approximately half of the 18 developed market equity indices and in the resulting country-average for diverse formation periods. The evidence from Sharpe ratios suggests that there is not a simple risk-based explanation for the TSR effect. This new evidence of a time-series long-term reversal effect complements the pre-existing evidence in the literature of a time-series momentum effect by Moskowitz et al. (2012).

4.2. Relationship between TSR and Cross-Sectional Reversal

It is natural to consider the implications of our evidence of a time series return reversal effect for traditional cross-sectional studies of long-term return reversal. Cross-sectional reversal results using international market indices have been reported by a number of authors, including Richards (1997), Balvers and Wu (2006), and Malin and Bornholt (2013). This section investigates the relevance of TSR to the cross-sectional evidence.

Our approach is as follows. Depending on the length of the holding period, we have identified that approximately half of the 18 developed markets country indices display a TSR effect in annual return differences. Specifically, in the 60-month formation case in Table 3 there are nine countries with significant or weakly significant Year 1 annual return differences. Call these nine the 'TSR' countries. They are Australia, Belgium, Canada, Denmark, France, Germany, Norway, Sweden and Switzerland. Call the remaining nine countries (Austria, Hong Kong, Italy, Japan, the Netherlands, Singapore, Spain, the United Kingdom, and the USA) the 'Non-TSR' countries. To test the relevance of TSR to cross-sectional results, we next conduct a standard cross-sectional analysis based first across all 18 country indices, then across only the TSR country indices, and then across just the Non-TSR country indices.

For each of these three sets of countries, portfolios are constructed as follows: At the beginning of each month *t*, indices are ranked based on their past 60-month formation period

returns. The cross-sectional long-term loser equal-weighted portfolio (LO_{CS}) contains the 25% of indices with the lowest returns, and the long-term winner equal-weighted portfolio (HI_{CS}) contains the 25% of indices with the largest returns. The strategy $LO_{CS} - HI_{CS}$ is long the long-term loser portfolio and is short the long-term winner portfolio. To increase test power, we employ the overlapping portfolio approach of Jegadeesh and Titman (1993, 2001). Holding periods for K = 3, 6, 9, or 12 months commence 12 months after formation. Annual returns (Year 1, Year 2, Year 3, Year 4, and Year 5) are the average annual returns in percentages for the first five years following the portfolio formation date.

Table 6 presents the cross-sectional contrarian strategy average monthly $LO_{CS} - HI_{CS}$ holding period returns in percentages derived from all 18 developed market country indices (Panel A), the subset of nine TSR country indices (Panel B), and the subset of nine Non-TSR country indices (Panel C) for the sample period January 1970 to March 2016. The $LO_{CS} - HI_{CS}$ holding period returns in Panel A range from 0.35% to 0.39% per month and are significant at the 5% level for all holding periods, except for K = 6 months. For example, the strategy earns 0.35% per month (t-stat 1.99) for 12-month holding periods. The $LO_{CS} - HI_{CS}$ holding period returns in Panel B are much stronger (ranging from 0.53% to 0.62% per month) and are all significant at the 1% level. In stark contrast, the $LO_{CS} - HI_{CS}$ holding period returns in Panel C are not statistically significant, and range from just 0.24% to 0.27% per month. Similar variations between the different panel results can be seen in the Year 2 returns.

In summary, cross-sectional profits based only on the TSR countries (Panel B) in this case are large and highly significant, whereas cross-sectional profits based only on Non-TSR countries (Panel C) are weak and not significant. Although perhaps not unexpected, these differences illustrate the potential influence that individual time series effects can have on cross-sectional outcomes. This section has also demonstrated the potential benefits that can

arise from studying the dynamics of individual time series rather than simply analyzing the dynamics of portfolios that are constructed by combining signals from individual time series.

Table 6 Profitability of the cross-sectional (60/K) contrarian strategies (Long/Short)

This table presents the average monthly holding period returns in percentages of the long – short portfolios of the cross-sectional contrarian strategy derived from all 18 developed market country indices (*Panel A*), the subset of nine TSR country indices (*Panel B*), and the subset of nine Non-TSR country indices (*Panel C*). The TSR Countries (Australia, Belgium, Canada, Denmark, France, Germany, Norway, Sweden, and Switzerland) are the nine countries from Table 3 with significant or weakly significant Year 1 average return differences, while the Non-TSR countries are the remaining countries (Austria, Hong Kong, Italy, Japan, the Netherlands, Singapore, Spain, the United Kingdom, and the USA). For each set of countries, portfolios are constructed as follows: At the beginning of each month *t*, indices are ranked based on their past 60-month formation period returns. The cross-sectional long-term loser equal-weighted portfolio (LO_{CS}) contains the 25% of indices with the lowest formation returns, and the long-term winner equal-weighted portfolio (HI_{CS}) contains the 25% of indices with the largest formation returns. The strategy $LO_{CS} - HI_{CS}$ is long the long-term loser portfolio and is short the long-term winner portfolio. Holding periods for K = 3, 6, 9, or 12 months commence 12 months after formation. Annual returns (Year 1, Year 2, Year 3, Year 4, and Year 5) are the average annual returns in percentages for the first five years following the portfolio formation date. The *t*-statistics are presented in parentheses. Holding period *t*-statistics are simple *t*-statistics, whereas the annual return *t*-statistics are based on the Newey–West (1987) correction for autocorrelation up to lag 11.

Note: *, **, *** denote significance at the 10%, 5%, and 1% levels, respectively.

	Holding Period Returns				**Annual Returns**				
Portfolio	***K = 3***	***K = 6***	***K = 9***	***K = 12***	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Panel A: All Countries (18)									
$LO_{CS} - HI_{CS}$	0.39**	0.35*	0.36**	0.35**	2.47	4.88**	4.03*	2.50	1.75
	(2.08)	(1.94)	(2.00)	(1.99)	(1.13)	(2.29)	(1.79)	(1.33)	(0.87)
Panel B: TSR Countries (9)									
$LO_{CS} - HI_{CS}$	0.62***	0.57***	0.54***	0.53***	7.12***	6.39***	5.35**	1.24	-0.33
	(2.98)	(2.90)	(2.80)	(2.86)	(2.81)	(2.68)	(2.07)	(0.46)	(-0.11)
Panel B: Non-TSR Countries (9)									
$LO_{CS} - HI_{CS}$	0.24	0.27	0.26	0.24	-1.04	3.87	4.80*	6.33*	6.22*
	(0.91)	(1.05)	(1.01)	(0.97)	(-0.40)	(1.31)	(1.74)	(1.76)	(1.65)

4.3. TSR Trading Strategy Profitability

Having established the existence of the long-term TSR effect, we investigate the exploitability of this TSR effect using the contrarian TSR trading strategies in this section. To do this, we construct 27 TSR(J, K) strategies across the three formation periods (J = 48, 60, 72) and nine holding periods (K = 1, 3, 6, 9, 12, 24, 36, 48, 60) and evaluate their returns. Recall that the TSR strategy return consists of the equally weighted average return from all of the long/short positions of the participating countries. To avoid look-ahead bias, the sample

contains all 18 country indices' returns rather than just the returns of the set of nine countries called TSR countries in the previous section.

Table 7 presents the average monthly excess returns ($r_t^{TSR(J,K)}$) for the various long-term TSR strategies. The Table is split into two panels: *Panel A* called 'Immediate' and *Panel B* called 'Skip 12 months'. 'Immediate' means that there is no gap between the end of the *J*-month formation period and the start of the *K*-month holding period, whereas 'Skip 12 Months' means that there is a gap of 12 months between the end of each formation period and the start of each holding period. A gap of 12 months is a common technique in cross-sectional studies of long-term reversal to allow for any short-term momentum to dissipate (see, for example, Fama & French, 1996; Malin & Bornholt, 2013).

Panel A shows that all of the TSR-based trading strategies earn positive excess returns. For example, in *Panel A* the J = 60 base case achieves significance at the 5% level for all holding periods from 6 months to 60 months, peaking with an average excess return of 0.54% per month (*t*-statistic 3.38) for K = 24 months. Similar patterns are found for the J = 48 and J = 72 months cases with a shift of one year backwards and one forward, respectively. In the J = 48 months case, all holding periods between 24 and 60 months produce highly significant results. In the J = 72 months case, all holding periods between one month and 48 months yield significant results.

The delayed TSR strategy results in *Panel B* tend to be stronger than those in *Panel A*. For example, in *Panel B* the J = 60 base case achieves significance at the 5% level for all holding periods from 1 month to 48 months, peaking with an average excess return of 0.59% per month (*t*-statistic 3.36) for K = 12 months. In the J = 72 months case, strategy profits are significant at the 1% level for all holding periods. The pervasiveness of significant TSR strategy excess returns across a broad range of (*J, K*) combinations provides strong and robust evidence of the exploitability of the time-series reversal effect.

Table 7 Average Excess Returns of various (J/K) contrarian strategies (Long/Short)

Panel A Immediate	Formation (in months)		Holding Period (K months)								
			1	3	6	9	12	24	36	48	60
	48	Av. Return	0.18	0.24	0.30*	0.30*	0.30*	0.39**	0.44***	0.37***	0.27**
		t-statistic	(0.91)	(1.31)	(1.65)	(1.68)	(1.76)	(2.36)	(2.93)	(2.85)	(2.55)
	60	Av. Return	0.32*	0.34*	0.42**	0.45**	0.45***	0.54***	0.44***	0.35***	0.26***
		t-statistic	(1.67)	(1.83)	(2.28)	(2.51)	(2.62)	(3.38)	(3.12)	(2.94)	(2.59)
	72	Av. Return	0.45**	0.44**	0.51***	0.53***	0.52***	0.43***	0.30**	0.24**	0.17*
		t-statistic	(2.49)	(2.53)	(3.03)	(3.22)	(3.31)	(2.99)	(2.40)	(2.14)	(1.69)
Panel B Skip 12 months											
	48	Av. Return	0.28	0.35*	0.39**	0.43**	0.45**	0.48***	0.37**	0.25**	0.15
		t-statistic	(1.45)	(1.81)	(2.07)	(2.35)	(2.50)	(2.83)	(2.51)	(2.10)	(1.47)
	60	Av. Return	0.510***	0.54***	0.56***	0.58***	0.59***	0.41***	0.32**	0.23**	0.12
		t-statistic	(2.70)	(2.91)	(3.07)	(3.26)	(3.36)	(2.64)	(2.41)	(1.98)	(1.14)
	72	Av. Return	0.75***	0.79***	0.80***	0.81***	0.79***	0.78***	0.71***	0.63***	0.54***
		t-statistic	(4.06)	(4.33)	(4.41)	(4.48)	(4.46)	(4.79)	(5.01)	(4.91)	(4.56)

The *Panels A* and *B* report average monthly excess strategy returns ($r_t^{TSR(J,K)}$) and the respective *t*-statistics. The average monthly excess returns are presented in percentages and the *t*-statistic in parentheses. To determine the *long/short* position for each country index *i* in each month *t*, the prior *J*-month rolling returns are compared with the CRSP *VW* quartile threshold levels; excluded are the country indices in each month *t*, which fall in between those extreme thresholds. The equal-weighted portfolio only consists of those countries indices that classify for a *long* or *short* position. The *J*-month formation and *K*-months holding periods are displayed in the first column and row, respectively. Across all three formation periods (*J* = 48, 60 and 72 months) and nine holding periods (*K* = 1,3,6,9,12,24,36,48 and 60 months), the table presents 27 different monthly TSR strategy results in *Panel A* and *B*. For holding periods longer than one month, the overlapping portfolios approach of Jegadeesh and Titman (1993) is used. 'Immediate'(*Panel A*) means there is no gap between the end of the formation period and the beginning of the holding period, whereas 'Skip 12 months' (*Panel B*) means there is a 12-month gap between the end of the formation period and the beginning of the holding period.
Note: *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

Figure 2 plots the post-formation monthly excess returns of the *K* = 1 strategies and the significance levels through time. The three panels illustrate the average magnitude and *t*-statistic of post-formation excess returns from one to 60 months. The months for which the line exceeds the horizontal *t*-statistic (1.96) indicate significant post-formation excess strategy returns at the 5% significance level for that month. These graphs provide more-detailed information about the timing structure and duration of the reversal effect. Overall, *Panel B* shows that the base case, (*60,1*) strategy, provides the longest lasting significant evidence of the TSR effect, consisting of 26 significant monthly returns compared with 16 months for the (*48,1*) strategy in *Panel A* and 20 months for the (*72,1*) strategy in *Panel C.* The minimum

Panel A

Panel B

Panel C

Figure 2. Average monthly excess returns profitability based on the strategy

Panel A, *B* and *C* plot the monthly average excess returns generated by a contrarian TSR strategy accounting for past performance across formation periods (J = 48, 60 and 72). The bars, which are scaled to the left axis, indicate the average excess monthly returns. The line indicating the *t*-statistics and the horizontal dotted line providing the 5% significance level (critical *t*-statistic= 1.96) are both scaled to the right axis. The months that the hashed line cuts the solid line from below (above) indicate the start (end) of periods with significant post-formation average monthly returns.

duration of the TSR effect over at least 16 months across diverse formation periods provides the further evidence of the long-term TSR effect.

To test whether significant TSR strategy results could have a risk-based explanation, we examine TSR strategy returns using the two-factor and three-factor regression models found in equations (1) and (2). Table 8 reports the monthly alphas and associated *t*-statistics for these regressions for each of the TSR*(J,K*) strategies. While *Panel A* provides the equation (1) alphas, *Panel B* reports the alphas for the equation (2). Each panel is further split into two subpanels: 'Immediate' and 'Skip 12 months'. As for the previous table, 'Immediate' means that there is no gap between the end of the *J*-month formation period and the start of the *K*-month holding period, whereas 'Skip 12 Months' means that there is a gap of 12 months between the end of each formation period and the start of each holding period.

The results in Table 8 show significant alphas for all formation periods and most holding periods. The (*60,24*) strategy without gap, for example, exhibits a highly significant 0.55% monthly alpha (*t*-statistic 3.17) from the MSCI regression in *Panel A*, which is very similar to the alpha value of 0.53% (*t*-statistic 2.82) from the Fama-French three-factor regression in *Panel B*. When skipping 12 months, the (*60,12*) strategy produces an alpha of 0.64% per month (*t*-statistic 3.53) in *Panel A* and an alpha of 0.61% per month (*t*-statistic 3.15) in *Panel B*. Overall, the effect of skipping 12 months does increase the number of significant alphas. While in the 'Immediate' case there are 16 significant alphas in *Panel A* and 15 significant alphas in *Panel B,* skipping the first year after formation provides stronger results with 21 significant alphas in *Panel A* and 19 in *Panel B* from all 27 strategies.

The significant alphas in Table 8 show that TSR strategy profits cannot be explained by either of the two asset pricing models and their risk factor considerations. This conclusion is reinforced by the observation that the 'Immediate' alphas in Table 8 are very similar in magnitude to the corresponding average excess returns in Table 7. For example, the TSR(*60, 12*) strategy has risk-adjusted alphas of 0.43% and 0.41% per month in *Panels A* and *B* of Table 8. These values are close

to the corresponding average excess return of 0.45% from Table 7. Thus, the results in Table 8 provide further evidence of the long-term time-series reversal effect, and show that this effect is exploitable using trading strategies. In summary, Tables 7 and 8 document evidence of a long-term TSR effect across both average excess returns and risk-adjusted returns.

To further illustrate potential applications of the time-series reversal effect, we consider long-only versions of the TSR base case (J = 60) strategy. The long-only TSR strategy return with K = 1 in month t is the equally-weighted average of those country index returns whose most-recent J-month return is below the external CRSP VW_{LO} benchmark. If no country qualifies for inclusion for a particular month, then the strategy adopts a long position in Treasury Bills for that month. The long-only TSR strategies for K = 3, 12, 24 are derived from the K = 1 strategy using the Jegadeesh and Titman (1993, 2001) overlapping portfolio approach. Comparing these TSR strategies' returns with the returns of the diversified 'buy-and-hold' (BnH) strategy from being long the MSCI World Index will allow us to evaluate the economic significance of these strategies for long-only investors.

Figure 3 graphs the wealth outcomes through time from investing $1 into each of these strategies at the start of January 1977. Overall, all TSR strategies outperform the BnH strategy over time. An advantage of the long-only TSR strategies with $K > 1$ is that they do not experience the sharp declines exhibited by the market BnH strategy returns during some periods associated with sharp market declines. The long-only TSR strategies method selectively chooses country indices with recent *LO* 60-month returns while investing solely in Treasury Bills when no country has just experienced a *LO* 60-month return. This process lowers market risk exposure while at the same time avoiding equity markets that may be more likely to decline. For example, the TSR(*60,1*), TSR(*60,6*) and the TSR(*60,12*) strategies outperformed the market BnH during the October 1987 crash. Similarly, the TSR(*60,6*) and TSR(*60,12*) strategies performed the best during the 2008 financial crisis. The TSR(*60,6*) strategy performs the best overall.

Table 8 Alphas and *t*-statistics of time series reversal strategies (*J, K*) (Long/short)

Panel A: MSCI Regression

Immediate:		**1**	**3**	**6**	**9**	**12**	**24**	**36**	**48**	**60**
48	**alpha**	0.00	0.12	0.20	0.23	0.27	0.41**	0.50***	0.43***	0.32***
	t-statistic	(-0.01)	(0.61)	(1.01)	(1.19)	(1.39)	(2.27)	(3.09)	(3.24)	(3.04)
60	**alpha**	0.19	0.25	0.35*	0.40**	0.43**	0.55***	0.47***	0.37***	0.27***
	t-statistic	(0.94)	(1.24)	(1.72)	(2.04)	(2.21)	(3.17)	(3.10)	(3.02)	(2.66)
72	**alpha**	0.38*	0.38*	0.46**	0.50***	0.51***	0.45***	0.31**	0.26**	0.18*
	t-statistic	(1.90)	(1.95)	(2.49)	(2.75)	(2.92)	(2.91)	(2.46)	(2.25)	(1.75)
Skip 12 months										
48	**alpha**	0.38*	0.43**	0.48**	0.54***	0.56***	0.59***	0.46***	0.32***	0.20**
	t-statistic	(1.86)	(2.16)	(2.47)	(2.82)	(3.01)	(3.48)	(3.24)	(2.72)	(1.98)
60	**alpha**	0.56***	0.58***	0.60***	0.63***	0.64***	0.45***	0.33**	0.23*	0.11
	t-statistic	(2.79)	(2.97)	(3.13)	(3.39)	(3.53)	(2.81)	(2.47)	(1.94)	(1.03)
72	**alpha**	0.49***	0.44**	0.41**	0.40**	0.36**	0.20	0.17	0.10	0.038
	t-statistic	(2.70)	(2.43)	(2.37)	(2.45)	(2.36)	(1.48)	(1.33)	(0.81)	(0.31)

Panel B: Fama-French Regression

Immediate		**1**	**3**	**6**	**9**	**12**	**24**	**36**	**48**	**60**
48	**alpha**	-0.06	0.09	0.18	0.22	0.25	0.40**	0.48***	0.41***	0.30***
	t-statistic	(-0.27)	(0.43)	(0.87)	(1.06)	(1.20)	(2.08)	(2.76)	(2.96)	(2.79)
60	**alpha**	0.14	0.23	0.33	0.39*	0.41**	0.53***	0.44***	0.35***	0.25**
	t-statistic	(0.66)	(1.07)	(1.54)	(1.84)	(2.00)	(2.82)	(2.77)	(2.74)	(2.43)
72	**alpha**	0.34	0.34	0.42**	0.463**	0.48**	0.43***	0.29**	0.23**	0.16
	t-statistic	(1.58)	(1.63)	(2.12)	(2.38)	(2.54)	(2.59)	(2.17)	(2.00)	(1.47)
Skip 12 months										
48	**alpha**	0.37*	0.43**	0.48**	0.54***	0.55***	0.58***	0.45***	0.31**	0.19*
	t-statistic	(1.72)	(2.05)	(2.36)	(2.68)	(2.84)	(3.15)	(3.00)	(2.55)	(1.83)
60	**alpha**	0.53**	0.55***	0.58***	0.60***	0.61***	0.43**	0.31**	0.21*	0.087
	t-statistic	(2.49)	(2.67)	(2.79)	(3.03)	(3.15)	(2.53)	(2.25)	(1.74)	(0.80)
72	**alpha**	0.49**	0.43**	0.40**	0.39**	0.35**	0.17	0.15	0.072	0.00
	t-statistic	(2.47)	(2.21)	(2.15)	(2.21)	(2.14)	(1.27)	(1.13)	(0.56)	(0.02)

Reported are the risk-adjusted returns (regression alphas) of TSR strategies, and their respective *t*-statistics for three formation (J = 48, 60, 72) and nine holding periods (K = 1, 3, 6, 9, 12, 24, 36, 48, 60). Each alpha (α) is reported as percentage per month, with its associated *t*-statistic in parentheses. Each strategy's monthly excess returns are regressed on two or three factors. The two factors for the MSCI regressions in *Panel A* are the MSCI World Index monthly excess return and the monthly return on the MSCI value factor, *VmG*. The three Fama and French regression factors in *Panel B* are the monthly excess return on the MSCI World Index, and the Fama and French size and value factors (*SMB* and *HML*). 'Immediate' denotes that there is no gap between the end of the formation period and the beginning of the holding period, whereas 'Skip 12 Months' denotes a 12-month gap between the end of the formation period and the beginning of the holding period.

Note: *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

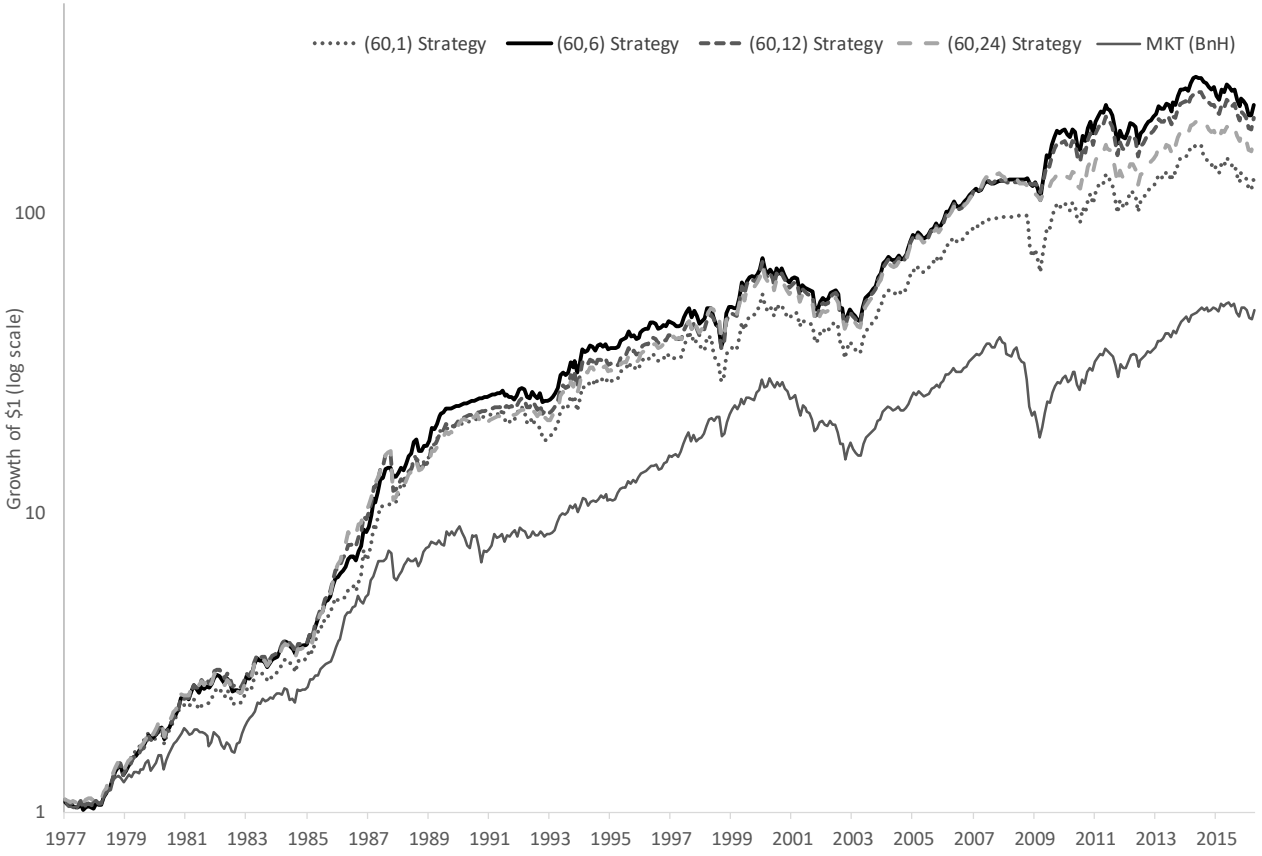


Figure 3 Long-Only TSR strategy performance Plotted are the overlapping long-only TSR strategy wealth outcomes through time from investing $1 at the start of 1977 for the J = 60 case and various holding periods (K=1, 6, 12, 24). In periods in which no country's returns classify for a long position in the market, the strategy invests in the Treasury bills. The long-only TSR strategy performances are compared to investing $1 at the start of 1977 in the "buy-and-hold" (BnH) strategy of investing solely in the MSCI World index for the time horizon from January 1977 to March 2016.

The annual Sharpe ratios for the TSR(*60,1*), TSR(*60,6*), TSR (*60,12*), and TSR(*60,24*) long-only strategies are 0.50, 0.59, 0.57, and 0.53, respectively, all considerably larger than the BnH Sharpe ratio of 0.40. Another measure of the riskiness of a trading strategy that is of particular interest to practitioners is the strategy's maximum drawdown (Antonacci, 2014; Hurst et al., 2012). Maximum drawdown measures a strategy's worst-case performance from peak to trough. The BnH strategy experiences a maximum drawdown of 53.7% over the timeframe from 1977 to 2016 compared to 39.1%, 40.1%, 39.2% and 38.3% for the TSR(*60,1*), TSR(*60,6*), TSR (*60,12*), and TSR(*60,24*) long-only strategies, respectively. Thus, we see that the long-only TSR strategies also deliver lower

downside risk exposure than the BnH strategy. This result is consistent with the outperformance of the long-term TSR strategies over the BnH strategy observed in Figure 3.

The impact of transaction costs on strategy profitability is also worth considering. Note that there are features of these strategies that assist in keeping transaction costs low. Firstly, the MSCI country developed market indices are each tradable in the form of exchange traded funds (ETFs) or futures, and each index consists only of large, liquid stocks. Secondly, contrarian strategies that select stocks based on their long-term past returns show a persistent trading signal which helps reduce transaction intensity. Thirdly, the approach of overlapping portfolios with longer than one month holding periods further reduces transaction intensity (Gârleanu & Pedersen, 2013; Jegadeesh & Titman, 1993).

In estimating the impact of transaction costs on the TSR strategies, we follow a number of studies which employ re-balancing strategies and which use transaction costs of 20 basis points per transaction for institutional investors[8]. Given that the longer the holding period the lower the transaction costs, the $K = 1$ case of the long-only TSR strategy will have the largest transaction frequency and hence the highest transaction costs in our study. The $K = 1$ strategy's trading frequency combined with the assumed cost of 20 basis points per transaction produces average monthly transaction costs of 0.067% for this strategy. This level of transaction costs does not significantly affect the monthly TSR*(60,1)* strategy return of 1.16% plotted in Figure 3. Consequently, it is reasonable to assume that transaction costs are unlikely to significantly impact the profitability of the other TSR strategies.[9]

[8] See Antonacci (2014), He & Li (2015), Jegadeesh (1990) and Jegadeesh & Titman (1993).

[9] Despite these arguments, we also examined the strategy returns using a 0.5% transaction costs and find that the returns of the TSR strategy are still not significantly impacted by transaction costs.

5. Conclusion

Recent studies examining the time-series predictability of financial assets mostly focus on predicting future returns using past short-term returns. The resulting gap in the empirical literature motivated our interest to investigate whether a time series' past long-term returns could be used to successfully predict its own future returns.

In this paper, we apply a time-series approach to investigate the existence of long-term return reversal in 18 MSCI developed market equity indices. The main parameter of interest is the return difference between the returns subsequent to low performing periods compared to the returns following high performing periods. If there is long-term return reversal then returns following low long-term returns will tend to outperform those returns following high long-term returns.

We document significant positive return differences at the individual country level in approximately half of the individual country indices, as well as in the country-average over the first two years of the post-formation period. The relationship between long-term past performance and current returns provides strong evidence of a long-term TSR effect, reflecting intertemporal dependency of returns in a number of international developed equity market indices.

For the first year post-formation, our base case with 60-month formation periods produces eight countries with significant average return differences (Belgium, Canada, Denmark, France, Germany, Norway, Sweden and Switzerland), one country with a weakly significant return difference (Australia), and the other nine countries with insignificant return differences (Austria, Hong Kong, Italy, Japan, the Netherlands, Singapore, Spain, the United Kingdom, and the USA). These results are intriguing. For example, even though the Canadian and US indices are highly contemporaneously correlated (74.1% in our sample), the Canadian index produces a significant return difference of 22.9% whereas the US index produces the second lowest return difference of 4.1%. Such results are a challenge for both rational and behavioral explanations of long-term return reversal.

The results achieved by our TSR trading strategies further support evidence of a long-term TSR effect. Most of the 27 TSR strategies provide robust and significant average excess returns and significant risk-adjusted returns. Interpreting the results from a practical perspective, the economic significance of the TSR effect can also be observed in the outperformance of long-only TSR trading strategies over a buy-and-hold investment in the MSCI World Index.

Future research directions arising out of this study include examining the interplay with TS momentum in equity market indices and in other asset classes. Also worthy of further study are the potential reasons for the persistence and source of this effect across diverse international markets.

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