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Potential gains from predicting the timing of stock market persistence and mean reversion

Abstract

This paper undertakes to investigate the effectiveness of market timing between prior winners and losers in the global equity markets using Monte Carlo simulation over the period from 1 January 1999 to 31 December 2009. The winner and loser portfolios of 100 stocks are constructed based on the prior 36-month U.S. dollar returns of the Dow Jones (DJ) Sector Titans Composite constituents. The market timer is assumed to have varying accuracy in predicting market persistence and mean reversion, and switch between the winner and loser portfolios on a quarterly basis based on his/her predictions. Sensitivity analysis is conducted to determine whether it is more important to predict the timing of persistence versus mean reversion. The study results reveal that an effective market timing strategy could be devised for market timers with modest ability to predict the timing between global equity market persistence and mean reversion. Greater benefits are derived from improvements in the mean reversion timing accuracy versus persistence timing accuracy, even though only 19 out of 44 quarters are classified as periods of mean reversion in the examination period. The results from sensitivity analysis support the view that it is more important to predict the timing of mean reversion correctly than persistence. This outcome could be attributed to the resilient nature of the loser portfolio in turbulent times. The observation that the majority of the persistent quarters are bullish (65.52%) while the majority of the mean reversion quarters are bearish (60%) provides evidence of investor overreaction in the global equity markets.

Keywords: mean reversion, market timing, overreaction hypothesis, technical analysis.
JEL Classification: G11, G12, G14, G15.

Introduction

Mean reversion in the stock market refers to the price correction of undervalued or overvalued stocks towards their long-term equilibrium values. The overreaction hypothesis of De Bondt and Thaler (1985; 1987) attribute equity mean reversion to the consequence of investor overreaction in the stock market. When investors overreact to the arrival of new information (both good and bad), their trading behaviors lead stock prices to overshoot and the subsequent mean reversion is expected. According to the overreaction hypothesis, equity mean reversion could be observed when prior losers outperform prior winners in the stock market. The evidence of equity mean reversion based on tests of the overreaction hypothesis has been widely documented in many stock markets and over various time periods. Hsieh and Hodnett (2012) propose that since equity mean reversion is related to investor sentiment in the market, the timing of mean reversion could be predicted from the various stages of the economic cycle. Their study results reveal that equity mean reversion is most likely to take place in the downswing of the economic cycle as prior losers become more resilient than prior winners in turbulent times.

This paper undertakes to investigate the effectiveness of global market timing between prior stock market winners and losers over the period from 1 January 1999 to 31 December 2009. The winner and loser portfolios are constructed from the top 100 constituents of the Dow Jones (DJ) Sector Titans Composite based on their prior 36-month U.S. dollar returns. A market timing strategy is developed to switch between the winner and loser portfolios based on the predictions of a hypothetical market timer with quarterly portfolio revisiting frequency. The market timer is assumed to have varying accuracy in predicting the timing of market persistence and the timing of mean reversion. Persistence in the market refers to the periods in which securities are overbought and oversold due to investor overreaction. Mean reversion is defined as the subsequent correction of overbought and oversold securities. When the market timer predicts persistence in the market, a long position in the winner portfolio will be held; when mean reversion in the market is predicted, the market timer sells off the winner portfolio and uses the proceeds to purchase the loser portfolio. Various permutations of persistence and mean reversion prediction accuracy are tested based on Monte Carlo simulations. The potential gains to the market timing strategy are computed as the returns of the market timing strategy in excess of the market returns; and the effectiveness of the strategy can be determined by examining the minimum levels of accuracy required to predict market persistence and mean reversion in order to earn a meaningful risk-adjusted return.

If asset prices follow a random walk, a market timer's accuracy in timing the market is approximately 50%, as "guessing" is the best a market timer can do. Even if market persistence and mean reversion are evident as a result of investor overreaction, potential gains from market timing, in

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the presence of high trading expense, is unlikely. Theoretically, for investors to earn abnormal returns from predicting the timing of persistence and mean reversion, the market has to be less developed than the weak-form in the context of the efficient market hypothesis (EMH), which states that market timing tools based on historical price movements are ineffective as they have already been reflected in asset prices. Thus, studies conducted in this paper are essentially tests of the weak-form EMH.

1. Evidence of investor overreaction and the timing of mean reversion

Fama (1970) proposes the efficient market hypothesis (EMH) that categorizes capital markets into weak-form, semi-strong form and strong-form of efficiency based on the types of information that are incorporated in asset prices. The EMH is associated with the random walk hypothesis, which states that asset price movements are random and independent from previous prices. "*If the flow of information is unimpeded and information is immediately reflected in stock prices, then tomorrow's price change will reflect only tomorrow's news and will be independent of the price change today*" (Malkiel, 2003, p. 59). In the context of the EMH, market participants are rational expected utility maximizers who compete to act on the arrival of new information in an efficient market. The trading activities of market participants in an efficient market results in accurate information being reflected in asset prices at all times, leaving no rooms for riskless arbitrage. In a weak-form efficient market, investors have instant access to past price information and any past price trends are fully incorporated in asset prices. When the market is developed to a higher level of efficiency, any publicly-available information (in the case of a semi-strong form) or even inside information (in the case of the strong-form) cannot be used to earn abnormal returns as publicly-available information would have been reflected in asset prices and trading on inside information is prevented by security regulations. Stock price persistence or mean reversion is regarded as past price information. Thus, for a market timer to benefit from studying the timing of market persistence and mean reversion, the stock market has to be less efficient than the lowest form of efficiency in the context of the EMH.

De Bondt and Thaler (1985) propose the over-reaction hypothesis, suggesting that investors overweigh the arrival of new information, which causes stock prices to deviate from their long-term fundamental values. When investor overreaction is present in the stock market, one would expect prior losers to outperform prior winners when the subsequent mean reversion takes place. De Bondt and Thaler (1985; 1987) test the performance of portfolios formed by prior 36-month winners and losers on the New York Stock Exchange (NYSE) over the period from 1933 to 1982. They find that the loser portfolio outperforms the winner portfolio by 14.6%, on average, 36 months after portfolio formation. Although Chen (1988) argues that the results could be attributed to increases in market risk of the loser portfolio over time, Chopra, Lakonishok and Ritter (1992) find significant abnormal returns for the winner and loser portfolios on the NYSE after controlling for time-varying betas in their study over the period from 1931 to 1986.

Page and Way (1992) test the overreaction hypothesis on the Johannesburg Stock Exchange (now the JSE Ltd) over the period from 1974 to 1989. They find the cumulative abnormal returns between the loser and winner portfolios to be approximately 14.5%, on average, 36 months since portfolio formation. Schiereck, De Bondt and Weber (1999) test the profitability of contrarian portfolios formed based on prior 36- to 60-month returns on the Frankfurt Stock Exchange over the period from 1961 to 1991. Significantly positive abnormal returns earned by the contrarian portfolios against the DAX stock index are documented over the examination period. Forner and Marhuenda (2003) conduct similar research on the Spanish Stock Exchange over the period from 1963 to 1997, and find significantly positive abnormal returns for the contrarian portfolio formed by prior 60-month losers over the examination period.

In an attempt to establish the timing of mean reversion in the South African equity market, Hsieh and Hodnett (2011) form monthly-rebalanced winner and loser portfolios based on prior 36-month returns of the All Share Index (ALSI) constituents over the period from 1993 to 2009. Test results indicate that the time-series abnormal returns between the winner and loser portfolios are significantly negatively correlated. In a further study, Hsieh and Hodnett (2012) use the residuals of the global equity winner and loser portfolios from the capital asset pricing model (CAPM) and Fama and French (1993) 3-factor model as proxies for abnormal returns. It is found that the global equity loser portfolios accumulate positive abnormal returns primarily in turbulent times; while the winner portfolio accumulate positive abnormal returns primarily in the upswing of the economic cycle over the period from 1999 to 2008.

2. Potential gains from market timing

Tests conducted on potential gains from market timing generally provide an indication regarding benefits that could have been received if one were to possess a perfect timing ability, and subsequently test the likely gains from imperfect market timing based on probability analysis or Monte Carlo simulation. Sharpe (1975) tests the effectiveness of market timing between holding the Standard and Poor's (S&P) Composite Index when the market is bullish and switching to U.S Treasuries when the market is bearish over the period from 1934 to 1972. The perfect timing strategy yields 14.86% return per annum versus 10.64% per annum for the buy-and-hold strategy. This is achieved with 14.58% standard deviation for the perfect timing strategy versus 21.06% standard deviation for the buy-and-hold strategy. To test the potential gains based on imperfect market timing ability, various levels of prediction accuracy are tested in a binomial model, assuming that the market timer has equal prediction accuracy for both bull and bear market. It is found that benefits from market timing are only available to market timers with more than 74% prediction accuracy on a risk-adjusted basis. The author nevertheless indicates that there exists a bias when one assumes equal accuracy for predicting bull and bear markets, since there are more good years than bad years historically.

Chua, Woodward and To (1987) improve the methodology of Sharpe (1975) by allowing varying levels of accuracy for bull and bear forecasts to be tested on the Canadian Stock Exchange. Monte Carlo simulation is employed to forecast the possible outcomes of various permutations of prediction accuracy for bull and bear markets based on the mean, variance and covariance of returns between stocks and Treasuries over the period from 1950 to 1983. After 10,000 iterations are simulated for each permutation of forecasting accuracy between bull and bear markets, they conclude that it is more important to forecast bull markets correctly than bear markets. The win/loss ratios reveal that the extraordinary returns forgone in bull markets actually outweighs the benefits derived from avoiding the losses in the bear markets if one were to possess excellent bear market prediction accuracy but low bull market prediction accuracy. Similar conclusions are obtained by Droms (1989) who tests the potential gains to market timing in the U.S. stock markets over the examination period from 1926 to 1986. However, Shilling (1992, p. 48) holds a different view and argues that "*when a stock falls 50%, it must then double to get back to its original price, and by being absent during that decline, the shareholder has twice as much money to invest later. Being out of the market in the weakest months is very beneficial, even if the investor also misses the strongest months.*"

Clarke, Fitzgerald, Berent and Statman (1989) argue that since stocks outperform Treasuries 66% of the time based on the examination period of Sharpe (1975), a market timer with no timing ability acts like a buy-and-hold investor who is holding the winning asset (i.e. stocks) 66% of the time. However, Clarke et al. (1989) demonstrate that a market timer with a simple pricing model that includes changes in GNP as the single predictor of stock returns with an R-square of only 9% can achieve 5.9% annual return in excess of the buy-and-hold strategy. Clarke et al. (1989) conclude that even modest additional information can bring substantial advantage over the buy-and-hold strategy. They further argue that there is no reason to believe that outperforming the market is more difficult through market timing than through stock selection.

The research for market timing also extends to investigating the potential gains available from switching between different investment styles in the stock markets. Kester (1990) attempts to examine the predictive ability required to benefit from switching between small caps, large caps and Treasuries over the period from 1934 to 1988 in the U.S. stock markets with varying assumptions for transaction costs and portfolio revision frequency. The minimum advantage from perfect timing is achieved for switching between large caps and Treasuries with annual revision frequency at 2% transaction cost (5.46% annual return); the maximum advantage is achieved for switching between small caps and Treasuries with monthly portfolio revision at 0.25% switching cost (28.26% annual return). Kester (1990) also attempts to establish the minimum prediction accuracy required to benefit from imperfect market timing. The easiest timing strategy is to switch between small caps and large caps with quarterly revision frequency at 0.25% transaction cost (56% accuracy required); and the most difficult timing strategy is to switch between small caps and large caps with monthly revision frequency at 2% transaction cost (86% accuracy required). When incremental prediction gains are taken into account, it is found that the timing between small caps and Treasuries offers the most profitable opportunities in terms of both the minimum required prediction accuracy and incremental return advantages. Bauer and Dahlquist (2001) adopt a "roulette wheel" approach that generate simulations for random switches between U.S. large caps, small caps, long-term corporate bonds, long-term govern-ment bonds, intermediate government bonds and short-term Treasuries over the period from 1926 through 1999. Their results indicate that potential gains to market timing between asset classes are rare, and switches between fewer asset classes are more advantageous than more asset classes.

Beebower and Varikooty (1991) argue that previous tests on potential gains from market timing strategy require well beyond human life expectancy. Beebower and Varikooty (1991) conduct performance evaluation on 9 hypothetical market timers with varying abilities to recognize the starting and ending points of the bull and bear markets within reasonable time frame. Over the examination period from 1926 through 1989, 200 simulations are generated per manager based on a monthly rolling basis, within a reasonable time frame, in every 1-, 3- and 5-year period. Their results suggest that most of the superior market timing results is attributed to random luck rather than true timing skills of the managers over relevant measurement periods.

The investigation on market timing is also extended to the examination of the market timing abilities of money managers. Bello and Janjigian (1997) develop an extended Treynor-Mazuy (1966) model to distinguish the market timing and stock selection abilities of 633 actively-managed U.S. equity mutual funds over the period from 1984 to 1994. The results indicate significantly positive market timing ability for U.S. equity mutual funds over the examination period, especially those in the aggressive-growth investment objective categories. Fung, Xu and Yau (2002) investigate the performance of 115 global equity hedge funds over the period from 1994 to 2000. They find that although the fund managers under examination lack market timing ability, they possess superior security-selection ability. Philippas (2002) investigate the performance of 19 Greek mutual fund managers in terms of their market timing and security selection abilities over the period from 1933 to 1997 based on the framework of Treynor-Mazuy (1966) and Henriksson-Merton (1981). Study results reveal that none of the Greek mutual funds under investigation possess significant market timing ability over the examination period.

3. Data and sample

This study employs the Dow Jones (DJ) Sector Titans Composite constituents as the research database. This composite has a unique sector representation in that it is comprised of the top 30 international large cap stocks in each of the 19 second tier sectors defined by the Industry Classification Benchmark (ICB). The total return indexes denominated in U.S. dollars for the 570 composite constituents are extracted over the period from 1 January 1996 to 31 December 2009. As of 1 January 1999, the cumulative prior 36-month returns of sample stocks are computed monthly using the equation below:

$$CR(-36)_{i,t} = TR_{i,t-1} / TR_{i,t-37}, \qquad (1)$$

where $CR(-36)_{i,t}$ is the cumulative prior 36-month return of stock i at the beginning of month t; $TR_{i,t-1}$ is the total return index of stock i in month t-1 (i.e. at the beginning of month t); and $TR_{i,t-37}$ is the total return index of stock i in month t-37.

Equally-weighted winner and loser portfolios of 100 stocks are constructed based on the cumulative prior 36-month returns of sample stocks. The portfolios are rebalanced monthly with portfolio returns for the winner/loser portfolio P in month t calculated using equation (2):

$$R_{P,t} = \sum_{i=1}^{100} \left[(TR_{i,t} / TR_{i,t-1}) - 1 \right] / 100 . \qquad (2)$$

A monthly-rebalanced market proxy is constructed to reflect the performance of an equally-weighted portfolio of all sample stocks over the examination period. An equally-weighted market proxy is preferred to the cap-weighted DJ Sector Titans Composite index to avoid the cap drag inherent in a typical cap-weighted portfolio. More specifically, when investor overreaction is present in the market, cap-weighted portfolios tend to overweigh overvalued stocks and underweigh undervalued stocks, which prevents cap-weighted portfolios from being mean-variance efficient (Hsu, 2006). Thus, studies concerning investor overreaction generally adopt the equally-weighted methodology in constructing the benchmark portfolio.

4. Winners versus losers and the timing of mean reversion

The cumulative returns and historical drawdown of the winner and loser portfolios and the market proxy are illustrated in Figure 1 and Figure 2, respectively. The loser portfolio not only accumulates the highest value over the examination period, but is also more resilient in terms of historical drawdown compared to the winner portfolio and the market proxy. The winner portfolio outperforms the loser portfolio and the market proxy from 2004, but experience significant drawdown and reversal after the global financial crisis in 2008.

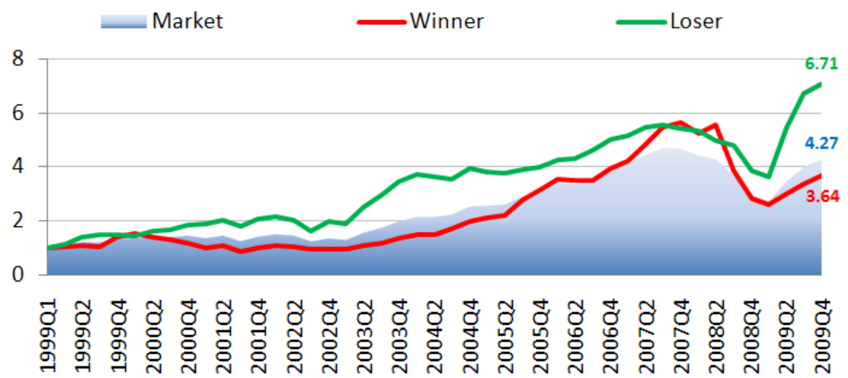

Fig. 1. Cumulative returns

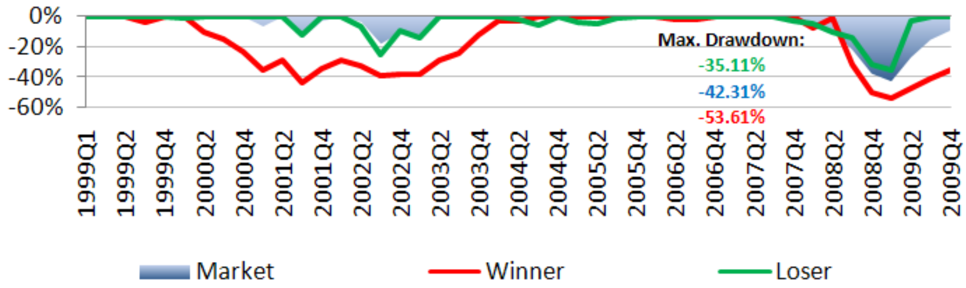

Fig. 2. Historical drawdown

Table 1 records the quarterly performance of the market proxy, U.S. 3-month Treasury (risk-free proxy), the winner and loser portfolios and the perfect timing strategy (inclusive and exclusive of trading costs). The perfect timing strategy is a strategy that invests in the winner portfolio during periods of market persistence; and switches over to the loser portfolio when mean reversion takes place. There are 15 switches in total required to implement the perfect timing strategy. The trading cost of 1% is assumed during switching. A persistence quarter is defined as the period in which the winner portfolio earns higher returns compared to the loser portfolio in the quarter; a mean reversion quarter is defined as the period in which the loser portfolio outperforms the winner portfolio. Similarly, bull and bear quarters are determined by comparing the quarterly market returns to the Treasury yield. When the market proxy earns higher quarterly returns relative to the Treasury yield, the period is defined as a bull quarter. On the other hand, when the market proxy underperforms the Treasury bill during the quarter, the period is considered as bearish.

Out of the 44 quarters in the examination period, there are 29 bull quarters compared to 15 bear quarters. On the other hand, 25 quarters are classified as persistence quarters, and 19 quarters are classified as mean reversion quarters. To demonstrate how investors tend to overvalue stocks when the market is bullish, and reverse their decisions in the subsequent bear markets, one can count how many bull quarters are also persistence quarters; and how many bear quarters coincide with mean reversion quarters.

Table 1. Historical performance (quarterly)

No.	Period	Market	Treasury	Winner	Loser	Perfect timing	Perfect timing (Cost adj.)	Bull or Bear?	Persistence or Reversion?
1	1999Q1	6.66%	1.11%	5.32%	14.64%	14.64%	14.64%	Bull	Reversion
2	1999Q2	12.71%	1.13%	4.01%	22.98%	22.98%	22.98%	Bull	Reversion
3	1999Q3	-0.98%	1.19%	-3.72%	5.26%	5.26%	5.26%	Bear	Reversion
4	1999Q4	10.86%	1.28%	34.12%	-0.44%	34.12%	33.12%	Bull	Persistence
5	2000Q1	2.22%	1.40%	8.70%	-0.68%	8.70%	8.70%	Bull	Persistence
6	2000Q2	2.69%	1.45%	-10.20%	10.18%	10.18%	9.18%	Bull	Reversion
7	2000Q3	0.69%	1.53%	-5.23%	3.75%	3.75%	3.75%	Bear	Reversion
8	2000Q4	3.21%	1.58%	-9.15%	10.94%	10.94%	10.94%	Bull	Reversion
9	2001Q1	-6.32%	1.19%	-16.05%	2.37%	2.37%	2.37%	Bear	Reversion
10	2001Q2	6.89%	0.93%	9.73%	6.51%	9.73%	8.73%	Bull	Persistence
11	2001Q3	-13.83%	0.84%	-21.12%	-11.63%	-11.63%	-12.63%	Bear	Reversion
12	2001Q4	12.79%	0.49%	17.53%	16.02%	17.53%	16.53%	Bull	Persistence
13	2002Q1	6.69%	0.43%	8.40%	4.48%	8.40%	8.40%	Bull	Persistence
14	2002Q2	-3.40%	0.43%	-6.08%	-6.58%	-6.08%	-6.08%	Bear	Persistence
15	2002Q3	-14.78%	0.42%	-9.47%	-19.27%	-9.47%	-9.47%	Bear	Persistence
16	2002Q4	8.85%	0.34%	2.06%	20.14%	20.14%	19.14%	Bull	Reversion
17	2003Q1	-4.22%	0.29%	-0.74%	-4.83%	-0.74%	-1.74%	Bear	Persistence
18	2003Q2	20.97%	0.26%	15.04%	34.34%	34.34%	33.34%	Bull	Reversion
19	2003Q3	11.41%	0.24%	6.51%	17.79%	17.79%	17.79%	Bull	Reversion
20	2003Q4	14.43%	0.23%	16.08%	15.77%	16.08%	15.08%	Bull	Persistence
21	2004Q1	7.65%	0.23%	10.73%	8.36%	10.73%	10.73%	Bull	Persistence
22	2004Q2	0.09%	0.27%	-0.16%	-2.06%	-0.16%	-0.16%	Bear	Persistence

Table 1 (cont.). Historical performance (quarterly)

No.	Period	Market	Treasury	Winner	Loser	Perfect timing	Perfect timing (Cost adj.)	Bull or Bear?	Persistence or Reversion?
23	2004Q3	3.92%	0.38%	13.99%	-3.21%	13.99%	13.99%	Bull	Persistence
24	2004Q4	13.88%	0.51%	16.74%	12.21%	16.74%	16.74%	Bull	Persistence
25	2005Q1	0.97%	0.64%	6.88%	-3.67%	6.88%	6.88%	Bull	Persistence
26	2005Q2	1.86%	0.73%	4.74%	-0.88%	4.74%	4.74%	Bull	Persistence
27	2005Q3	11.06%	0.85%	25.59%	3.38%	25.59%	25.59%	Bull	Persistence
28	2005Q4	5.81%	0.97%	11.84%	2.01%	11.84%	11.84%	Bull	Persistence
29	2006Q1	10.05%	1.11%	13.69%	6.81%	13.69%	13.69%	Bull	Persistence
30	2006Q2	0.08%	1.19%	-2.06%	0.98%	0.98%	-0.02%	Bear	Reversion
31	2006Q3	5.47%	1.25%	0.07%	7.69%	7.69%	7.69%	Bull	Reversion
32	2006Q4	10.79%	1.29%	12.82%	8.31%	12.82%	11.82%	Bull	Persistence
33	2007Q1	4.75%	1.22%	7.61%	2.67%	7.61%	7.61%	Bull	Persistence
34	2007Q2	7.78%	1.21%	14.02%	6.11%	14.02%	14.02%	Bull	Persistence
35	2007Q3	5.90%	1.13%	13.74%	1.87%	13.74%	13.74%	Bull	Persistence
36	2007Q4	-0.74%	0.87%	2.85%	-2.54%	2.85%	2.85%	Bear	Persistence
37	2008Q1	-5.33%	0.52%	-7.34%	-2.16%	-2.16%	-3.16%	Bear	Reversion
38	2008Q2	-3.31%	0.41%	6.48%	-6.02%	6.48%	5.48%	Bear	Persistence
39	2008Q3	-13.51%	0.39%	-30.39%	-4.27%	-4.27%	-5.27%	Bear	Reversion
40	2008Q4	-20.12%	0.07%	-26.65%	-19.62%	-19.62%	-19.62%	Bear	Reversion
41	2009Q1	-8.10%	0.05%	-7.92%	-5.89%	-5.89%	-5.89%	Bear	Reversion
42	2009Q2	27.27%	0.04%	14.62%	50.55%	50.55%	50.55%	Bull	Reversion
43	2009Q3	15.73%	0.04%	12.33%	23.53%	23.53%	23.53%	Bull	Reversion
44	2009Q4	7.06%	0.02%	8.57%	5.18%	8.57%	7.57%	Bull	Persistence
Quarterly statistics:									
Return:		3.78%	0.73%	3.83%	5.25%	9.77%	9.10%	Bull: 29	Persistence: 25
Std. deviation:		9.44%	0.48%	12.94%	12.71%	12.70%	12.75%	Bear: 15	Reversion:19
Sharpe ratio: Max. drawdown:		32.34% -42.31%	0.00% 0.00%	23.95% -53.61%	35.56% -35.11%	71.20% -27.59%	65.63% -28.34%		Switches:15

Note: The figures highlighted in bold in the Perfect timing column represent the periods in which switching between the winner portfolio and the loser portfolio or vice versa is required. To demonstrate how investors tend to overvalue stocks when the market is bearish, and reverse their decisions in the subsequent bear markets, the bull quarters and persistence quarters are highlighted in grey, while bear quarters and mean reversion quarters are highlighted in dark grey. Borders are also placed around consecutive matches between bull and persistent quarters; and bear and mean reversion quarters.

The bull quarters and persistence quarters are highlighted in grey while bear quarters and mean reversion quarters are highlighted in dark grey in Table 1. Borders are also placed around consecutive matches between bull and persistent quarters; and bear and reversion quarters. Out of 29 bull quarters, 19 of them are also classified as persistent quarters (65.52%). On the other hand, mean reversion takes place in 9 out of 15 bear quarters (60.00%). This counting exercise provides some evidence of investor overreaction in the markets, as winners are more likely to outperform losers in the bull markets; and losers are more likely to outperform winners in the bear markets. It is also observed that although mean reversion is most likely to occur in the bear quarters, the largest gain from timing mean reversion correctly actually comes from the bull quarters. For example, the loser portfolio gained 19.14% in the fourth quarter of 2002; 34.34% in the second quarter of 2003; 17.79% in the third quarter of 2003; 50.55% in the second quarter of 2009; and 23.53% in the third quarter of 2009. Since the loser portfolio represents stock investments that form parts of the market portfolio, the largest gains would come from the period in which stocks outperform bonds. The substantial returns at the end of 2002 and in 2009 are indeed the rebound from the significant drawdown in the previous quarters. Thus, it could be argued that the profitability of market timing depends not only on the precision of the predictions, but also on the degree of the persistence or mean reversion exhibited once the predictions are made. The statistics in Table 1 shows that although the loser portfolio has higher returns and lower risk compared to the winner portfolio over the examination period, it only outperformed the winner portfolio in 19 of the 44 quarters. This observation provides evidence of market timing for mean reversion; and offers incentives for investors to engage in the timing between stock market winners and losers.

5. Monte Carlo simulation

Monte Carlo simulation, named after the Monte Carlo Casino, is a computerized mathematical technique that generates hypothetical scenarios or observations from a predetermined probability distribution. The modern application of this technique was initially invented by a Polish-American scientist, Stanislaw Ulam in the late 1940s on a nuclear weapon project. To determine the effectiveness of the market timing strategy that switches between the winner and loser portfolios based on the market timer's predictions in the upcoming quarter using the Monte Carlo simulation technique, several assumptions need to be made regarding the method of forecasting and switching. The level of prediction accuracy is defined as the percentage of correct bets out of the total number of bets made by the market timer. The market timer is assumed to have different abilities in predicting market persistence and mean reversion in the upcoming quarter. The market timer's call of market persistence and mean reversion depends on a variety of factors, such as his/her views on the current and future states of the economy; the market timer's experiences and heuristics; the turning points observed from technical charts and indicators; signals generated by quantitative models, and so forth.

The following Monte Carlo simulation procedure is designed to evaluate the effectiveness of the market timing strategy for all permutations of prediction accuracies between market persistence and mean reversion from 10% to 100%, with 10% incremental increases. For each permutation of prediction accuracies between market persistence and mean reversion, 10,000 sets of 44 random numbers (N_1 to N_{44}) between 0% and 100% are generated from a normal distribution. Each of the 44 random numbers is assigned to the 44 quarters in the examination period. If a quarter is classified as persistence and the assigned level of prediction accuracy for persistence is greater than the assigned random number for the quarter, a hypothetical market timer is assumed to have a successful prediction and will invest in the winner portfolio for the quarter. Otherwise, the market timer will invest in the loser portfolio that earns a relatively lower return for the quarter. On the other hand, when mean reversion occurs in a particular quarter, the mean reversion timing accuracy is compared to the assigned random number for the quarter. The hypothetical market timer will invest in the loser portfolio if the prediction accuracy for mean reversion is greater than the assigned random number, and vice versa. Since N represents a normally-distributed random number with a mean of 50%, a market timer only has a higher probability of earning the higher return in the iteration if he/she possesses greater than 50% prediction accuracy. This simulation design is supported by the fact that a market timer who gets his/her predictions correct 50% of the time does not have any forecasting ability. A transaction cost of 1% is deducted during switching between the winner and loser portfolios. In each of the 10,000 iterations simulated under each permutation of forecasting accuracies, the average quarterly returns, standard deviation of quarterly returns, Sharpe ratio, potential gains, number of switches, the win/loss ratio and the maximum drawdown are estimated with their average values computed to provide an indication of the effectiveness of the strategy under each permutation.

The Sharpe ratio measures the excess portfolio return per unit of portfolio risk as shown in equation (3):

$$SR_P = (R_P - R_f) / \sigma_p, \tag{3}$$

where R_P stands for the average quarterly portfolio return for the timing strategy; R_f is the average quarterly yield on risk-free proxy; and σ_p is the standard deviation of the quarterly returns for the market timing strategy.

Potential gain is measured as the average simulated returns in excess of the market proxy returns over the 44 quarters in the examination period. The win/loss ratio measures the number of quarters during which the simulated timing returns are greater than the market proxy returns, relative to the number of quarters during which the simulated strategy earns less than the market proxy returns. Thus, a market timing strategy is considered effective only when the win/loss ratio is greater than one. The maximum drawdown of a portfolio refers to the largest loss from peak to trough over the examination period. The maximum drawdown of the timing strategy X over the period from quarter 0 to quarter T is depicted in equation (4):

$$MDD_{X,T} = \min_{t\in(0,T)}\left[CR_X(\tau) / \max_{t\in(0,T)} CR_X(t) - 1 \right], \tag{4}$$

where $0 \leq t \leq T$; and $CR_X(\tau)$ is the return accumulated from \$1 since $t = 0$ until trough τ following the quarter of the historical maximum cumulative return $\max_{t\in(0,T)} CR_X(t)$.

The estimated values of the average quarterly returns, standard deviation, Sharpe ratio, potential gains, number of switches, the win/loss ratio and maximum drawdown estimated under each permutation of timing accuracy are documented in Appendices A to G respectively. Panel (a) in each Appendix reports the performance measures of the timing strategy for each permutation of timing accuracy between persistence and mean reversion.

Borders are placed around permutations that outperform the market proxy in terms of returns in Appendix A, Sharpe ratio in Appendix C and potential gains in Appendix D. With regard to simulated timing strategy returns shown in Appendix A, random switches between the winner and the loser portfolios would be sufficient to earn higher returns (4.05%) than the market proxy (3.78%), with just 50% persistent timing ability and 50% mean reversion timing ability. The same result is indicated by the positive potential gains available with greater than 1.0 win/loss ratio for the joint 50% accuracy in predicting the timing for persistence and mean reversion (refer to Appendix D and Appendix F respectively). When portfolio risk is taken into account, a hypothetical market timer could achieve a higher Sharpe ratio (33.62%) relative to the market proxy (32.34%) if he/she has 60% accuracy in predicting the timing for persistence and mean reversion, as shown in Appendix C.

Although the simulated returns, potential gains, Sharpe ratio and the win/loss ratio all indicate that moderate levels of prediction accuracy are required to benefit from the timing strategy, simulated results in Appendix E indicate that many wrong switching signals are generated at low levels of prediction accuracy (+/- 20 switches), compared to the optimal number of switches (15 switches) in the case of 100% prediction accuracy. Thus, higher levels of predicting accuracy would be required if the rebalancing costs are higher than 1%. The analysis of the heat map in Appendix B reveals that the standard deviations of the timing strategy are higher than average when the accuracy for timing mean reversion is low, even if the persistence timing accuracy is close to 100%. However, the reverse is not true as lower levels of persistence timing accuracy do not necessarily raise the portfolio risk if the mean reversion timing accuracy is high. This implies that the ability of the market timer to predict the timing of mean reversion is crucial in managing the risk of the market timing strategy. This observation raises the question as to whether the ability to predict the timing of persistence or mean reversion is more important in the market timing strategy.

6. Sensitivity analysis

The objective of the sensitivity analysis is to determine the relative importance of predicting the timing of persistence versus mean reversion. Under the sensitivity analysis, the prediction accuracy for persistence (mean reversion) is fixed at 50% (i.e. random guesses), with the prediction accuracy for mean reversion (persistence) to be raised at a 10% increment, starting from 10%. The gradual improvements in the performance measures when the persistence prediction accuracy is fixed are then compared to the gradual improvements when the mean reversion prediction accuracy is fixed. If performance improvements are more sensitive to increases in the mean reversion prediction accuracy compared to increases in the persistence prediction accuracy, the results indicate that it is more important to predict the mean reversion timing correctly, relative to the timing of persistence.

The results of the sensitivity analysis are illustrated by the histograms in each Appendix. The blue histograms demonstrate the gradual improvements in the performance of the timing strategy when the persistence prediction accuracy is held constant at 50%. On the other hand, the red histograms indicate performance improvements when the mean reversion prediction accuracy is held constant. Chart (a) of Appendix A shows that strategy returns improves relatively faster when mean reversion prediction accuracy increases, while holding persistence prediction accuracy constant. Similarly, the Sharpe ratio and potential gains in Chart (a) of Appendix C and Appendix D are more sensitive to changes in the mean reversion prediction accuracy than changes in the persistence prediction accuracy. Although the starting points of the blue histograms are lower than that of the red histograms in Chart (a) of Appendix A, Appendix C and Appendix D, the blue histograms grow at faster rates and eventually exceed the red histograms. However, Chart (a) of Appendix F shows that the win/loss ratio improves faster when the persistence prediction accuracy increases. This result is expected since there are more persistence quarters (25 quarters) than mean reversion quarters (19 quarters), and more quarters are thus affected when the persistence prediction accuracy changes.

With regard to changes in portfolio risk, the portfolio risk of the strategy continues to increase when the persistence prediction accuracy increases, as shown in Appendix B. On the contrary, increases in the mean reversion prediction accuracy do not lead to higher portfolio risk. In addition, the maximum drawdown of the strategy declines faster when the mean reversion prediction accuracy increases, as shown in Appendix G. Overall, the mean reversion prediction accuracy seems to be more important than the persistence prediction accuracy in controlling the risk of the market timing strategy.

Conclusion

The timing of market persistence and mean reversion is evident in the global equity markets. Over the examination period from 1 January 1999 to 31 December 2009, the winner portfolio outperforms the loser portfolio in 19 of the 29 bull quarters (65.52%) while the loser portfolio outperforms the winner portfolio in 9 of the 15 bear quarters (60.00%). This observation suggests that investors are overconfident in the bull markets, which might lead to mean reversion when the market becomes bearish. It is also observed that although mean reversion is most likely to occur in the bear quarters, the largest gain from timing mean reversion correctly actually comes from the bull quarters following recent large drawdowns in the stock markets. Thus, it could be argued that the profitability of market timing depends not only on the precision of the predictions, but also on the degree of persistence or mean reversion exhibited once the predictions are made.

The results from Monte Carlo simulation indicate that potential gains are available to market timers with moderate ability to predict the timing of market persistence and mean reversion, and it is more important to predict the timing of mean reversion correctly than market persistence in the global equity markets. The returns and potential gains improve faster when the mean reversion prediction accuracy improves without introducing higher volatility in the portfolio. In addition, maximum drawdown declines faster when mean reversion prediction ability improves. As a result, the Sharpe ratio is more sensitive to changes in the predicting accuracy for mean reversion than persistence. Although the loser portfolio only outperforms the winner portfolio in 19 of the 44 quarters, overall, the loser portfolio is more mean-variance efficient than the winner portfolio, and the performance of the timing strategy improves faster with increases in the mean reversion prediction accuracy compared to increases in the persistence prediction accuracy. The fact that the maximum drawdown for the loser portfolio (-35.11%) is much lower compared to the winner portfolio (-53.61%), coupled with the fact that 60% of the mean reversion quarters are bearish, suggests that improvements in mean reversion prediction accuracy makes the timing strategy more resilient to economic shocks. If one were to use persistence periods as the proxy for bull markets and mean reversion periods as the proxy for bear markets, test results from this paper support the argument of Shiller (1992) in that it is more beneficial to avoid large losses from significant drawdown; but contradict Chua et al. (1987) who emphasize the importance of not missing the extraordinary returns in bull markets. Nevertheless, the persistence prediction accuracy is crucial for improvements in the win/loss ratio and reducing trading costs as there are more persistence quarters in the examination period.

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Appendix A. Returns

Persistence Prediction Accuracy \ Reversion Prediction Accuracy	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
10%	0.01%	0.51%	1.13%	1.77%	2.38%	3.00%	3.65%	4.27%	4.95%	5.61%
20%	0.39%	0.96%	1.56%	2.17%	2.79%	3.42%	4.03%	4.63%	5.33%	5.97%
30%	0.79%	1.43%	1.99%	2.58%	3.13%	3.78%	4.41%	5.02%	5.68%	6.31%
40%	1.26%	1.80%	2.48%	3.02%	3.61%	4.22%	4.85%	5.45%	6.05%	6.71%
50%	1.77%	2.28%	2.88%	3.46%	4.05%	4.73%	5.28%	5.92%	6.48%	7.14%
60%	2.24%	2.82%	3.35%	3.95%	4.53%	5.07%	5.70%	6.30%	6.94%	7.55%
70%	2.75%	3.29%	3.83%	4.44%	5.00%	5.56%	6.18%	6.82%	7.39%	8.06%
80%	3.23%	3.80%	4.35%	4.95%	5.48%	6.05%	6.61%	7.27%	7.87%	8.49%
90%	3.80%	4.33%	4.90%	5.40%	6.03%	6.55%	7.14%	7.70%	8.35%	8.95%
100%	4.35%	4.85%	5.43%	5.95%	6.48%	7.05%	7.67%	8.27%	8.81%	9.43%

Panel (a) Simulated permutations

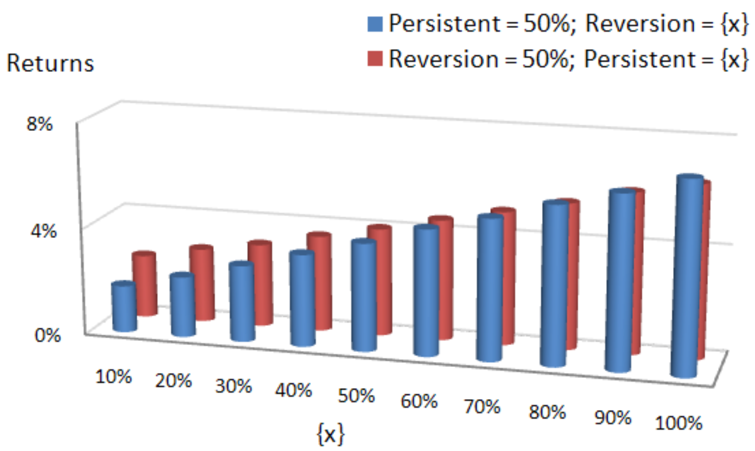

Chart (a) Sensitivity analysis

Appendix B. Standard deviation

		Reversion Prediction Accuracy									
		10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
	10%	11.33%	11.46%	11.74%	12.06%	12.24%	12.40%	12.47%	12.60%	12.73%	12.78%
	20%	11.52%	11.79%	11.98%	12.19%	12.35%	12.59%	12.59%	12.74%	12.80%	12.82%
Persistence	30%	11.75%	11.93%	12.21%	12.26%	12.49%	12.57%	12.69%	12.84%	12.85%	12.86%
Prediction	40%	12.00%	12.11%	12.37%	12.43%	12.60%	12.75%	12.81%	12.90%	12.86%	12.88%
Accuracy	50%	12.24%	12.35%	12.46%	12.61%	12.74%	12.88%	12.81%	12.90%	12.88%	12.91%
	60%	12.40%	12.55%	12.64%	12.85%	12.83%	12.95%	12.93%	12.98%	12.95%	12.89%
	70%	12.55%	12.72%	12.84%	12.81%	12.86%	13.00%	13.00%	12.97%	12.91%	12.89%
	80%	12.73%	12.86%	12.91%	12.95%	13.03%	13.03%	13.03%	12.99%	12.93%	12.84%
	90%	12.85%	12.93%	13.02%	13.09%	13.06%	12.98%	12.99%	12.98%	12.90%	12.78%
	100%	13.02%	13.10%	13.12%	13.08%	13.06%	13.07%	13.04%	12.91%	12.79%	12.70%

Panel (a) Simulated permutations

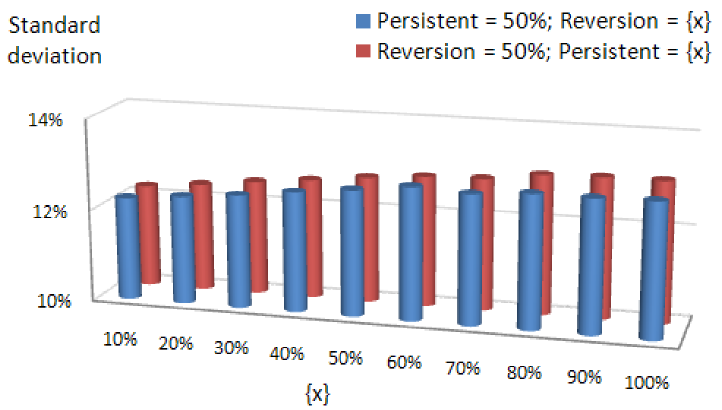

Chart (a) Sensitivity analysis

Appendix C. Sharpe ratio

		Reversion Prediction Accuracy									
		10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
	10%	-6.64%	-2.20%	3.14%	8.33%	13.29%	18.26%	23.39%	28.06%	33.16%	38.16%
	20%	-3.21%	1.63%	6.67%	11.63%	16.56%	21.30%	26.20%	30.60%	35.95%	40.81%
Persistence	30%	0.18%	5.54%	10.13%	14.93%	19.04%	24.30%	29.00%	33.47%	38.55%	43.40%
Prediction	40%	4.18%	8.63%	13.99%	18.31%	22.78%	27.41%	32.22%	36.65%	41.39%	46.38%
Accuracy	50%	8.29%	12.33%	17.08%	21.56%	26.00%	31.06%	35.59%	40.37%	44.74%	49.66%
	60%	11.97%	16.50%	20.65%	25.04%	29.72%	33.62%	38.59%	43.02%	48.05%	52.89%
	70%	15.96%	20.04%	24.05%	29.01%	33.27%	37.24%	42.06%	47.10%	51.74%	56.82%
	80%	19.55%	23.82%	28.03%	32.68%	36.60%	41.07%	45.35%	50.49%	55.33%	60.42%
	90%	23.89%	27.89%	32.09%	35.77%	40.71%	45.04%	49.65%	53.88%	59.27%	64.28%
	100%	27.80%	31.54%	35.93%	40.04%	44.24%	48.57%	53.44%	58.63%	63.35%	68.52%

Panel (a) Simulated permutations

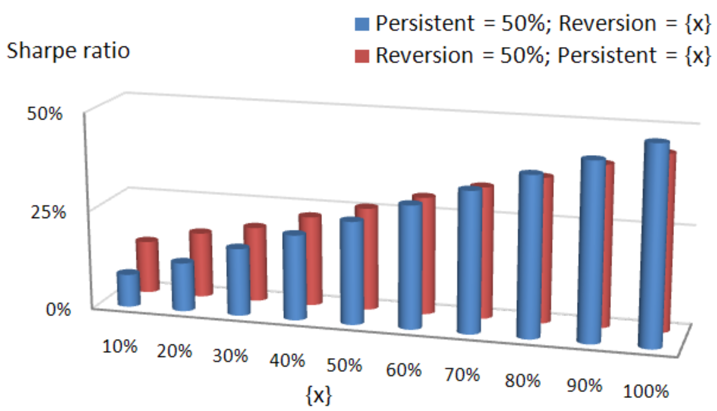

Chart (a) Sensitivity analysis

Appendix D. Potential gains

		Reversion Prediction Accuracy									
		10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
	10%	-3.78%	-3.28%	-2.65%	-2.02%	-1.41%	-0.78%	-0.14%	0.48%	1.16%	1.82%
	20%	-3.39%	-2.83%	-2.23%	-1.61%	-0.99%	-0.37%	0.24%	0.84%	1.54%	2.18%
Persistence	30%	-3.00%	-2.36%	-1.79%	-1.21%	-0.66%	0.00%	0.63%	1.23%	1.90%	2.53%
Prediction	40%	-2.52%	-1.98%	-1.30%	-0.76%	-0.18%	0.44%	1.06%	1.67%	2.26%	2.92%
Accuracy	50%	-2.01%	-1.51%	-0.91%	-0.32%	0.26%	0.94%	1.49%	2.14%	2.70%	3.36%
	60%	-1.55%	-0.97%	-0.43%	0.17%	0.75%	1.29%	1.92%	2.51%	3.15%	3.77%
	70%	-1.04%	-0.50%	0.04%	0.66%	1.22%	1.77%	2.40%	3.03%	3.61%	4.27%
	80%	-0.55%	0.01%	0.56%	1.16%	1.69%	2.27%	2.82%	3.48%	4.08%	4.70%
	90%	0.02%	0.55%	1.11%	1.61%	2.24%	2.77%	3.36%	3.91%	4.57%	5.16%
	100%	0.56%	1.07%	1.65%	2.17%	2.69%	3.26%	3.88%	4.49%	5.03%	5.65%

Panel (a) Simulated permutations

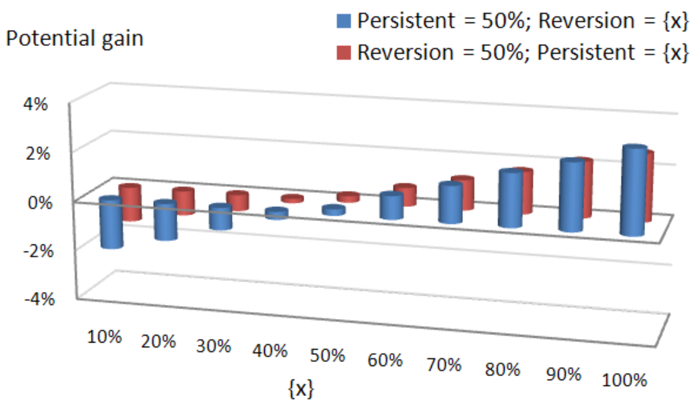

Chart (a) Sensitivity analysis

Appendix E. Number of switches

		Reversion Prediction Accuracy									
		10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
	10%	17	18	17	17	16	15	13	10	8	5
	20%	19	19	20	19	19	17	16	14	11	8
Persistence	30%	19	20	20	20	20	19	18	16	14	11
Prediction	40%	19	20	21	21	21	21	20	18	16	14
Accuracy	50%	18	19	21	21	21	21	20	19	18	16
	60%	17	18	20	20	21	21	21	20	19	17
	70%	14	16	18	19	20	20	20	20	19	18
	80%	11	14	16	17	18	19	19	19	19	18
	90%	8	10	13	15	16	17	18	18	17	17
	100%	3	6	9	11	13	14	15	16	15	15

Panel (a) Simulated permutations

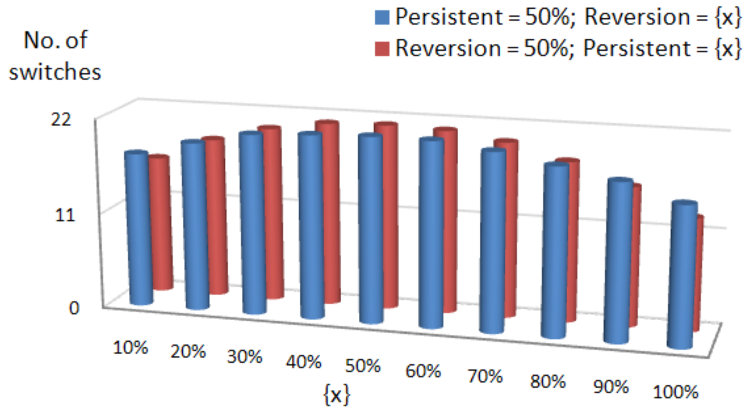

Chart (a) Sensitivity analysis

Appendix F. Win/Loss ratio

Persistence Prediction Accuracy	Reversion Prediction Accuracy: 10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
10%	0.21	0.27	0.33	0.41	0.50	0.59	0.71	0.84	1.00	1.19
20%	0.28	0.34	0.42	0.51	0.60	0.71	0.85	1.00	1.20	1.43
30%	0.35	0.43	0.52	0.61	0.72	0.86	1.02	1.19	1.43	1.69
40%	0.44	0.52	0.63	0.74	0.88	1.03	1.21	1.44	1.71	2.07
50%	0.55	0.64	0.75	0.88	1.04	1.25	1.48	1.76	2.08	2.55
60%	0.66	0.79	0.91	1.06	1.26	1.45	1.76	2.12	2.59	3.25
70%	0.80	0.93	1.08	1.28	1.52	1.79	2.15	2.65	3.31	4.34
80%	0.95	1.11	1.32	1.56	1.83	2.21	2.67	3.45	4.35	5.82
90%	1.16	1.35	1.59	1.85	2.28	2.76	3.45	4.33	5.99	8.42
100%	1.39	1.61	1.94	2.29	2.78	3.43	4.52	6.22	8.67	13.67

Panel (a) Simulated permutations

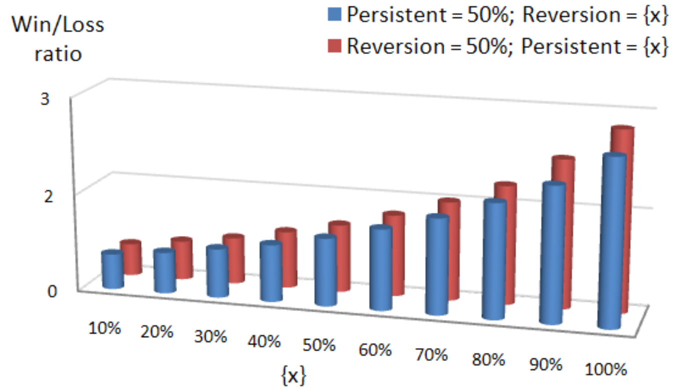

Chart (a) Sensitivity analysis

Appendix G. Maximum drawdown

Persistence Prediction Accuracy	Reversion Prediction Accuracy: 10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
10%	-60.3%	-57.8%	-55.2%	-52.7%	-50.2%	-46.5%	-43.6%	-41.1%	-37.7%	-34.4%
20%	-58.9%	-56.8%	-54.2%	-52.0%	-49.4%	-46.3%	-43.5%	-40.5%	-36.8%	-33.7%
30%	-58.1%	-56.0%	-53.8%	-51.4%	-48.8%	-45.5%	-43.2%	-39.3%	-36.2%	-32.9%
40%	-57.0%	-54.9%	-53.0%	-51.2%	-47.3%	-44.6%	-42.3%	-39.1%	-35.8%	-32.4%
50%	-56.3%	-53.9%	-52.1%	-49.3%	-47.0%	-43.8%	-40.9%	-37.8%	-34.6%	-31.7%
60%	-55.4%	-53.5%	-51.5%	-48.6%	-46.5%	-43.1%	-40.2%	-37.4%	-34.4%	-30.9%
70%	-54.7%	-52.6%	-50.3%	-47.6%	-45.4%	-42.1%	-40.0%	-36.5%	-33.5%	-30.3%
80%	-53.8%	-51.8%	-49.4%	-46.9%	-44.5%	-41.3%	-39.0%	-36.1%	-32.9%	-29.7%
90%	-52.9%	-50.8%	-48.7%	-46.0%	-43.6%	-41.1%	-37.9%	-35.1%	-32.0%	-29.1%
100%	-51.9%	-50.0%	-47.7%	-45.3%	-42.8%	-40.2%	-36.8%	-34.0%	-31.4%	-28.3%

Panel (a) Simulated permutations

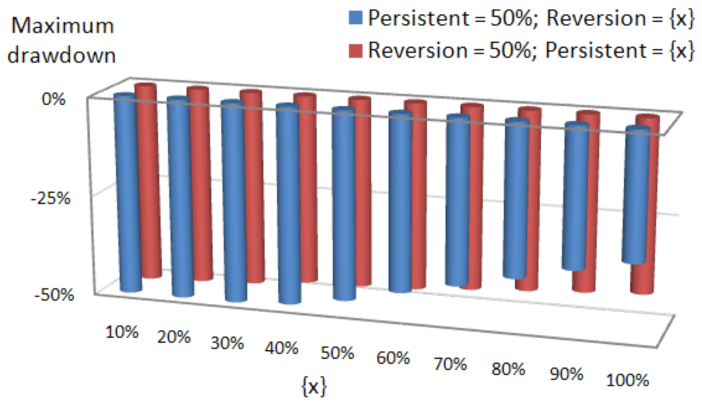

Chart (a) Sensitivity analysis