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Modified Dollar Cost Averaging Investment Strategy: Evidence from Taiwan Stock Market

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Abstract

This study aims to propose approaches for improving long-term annualized rate of return in investment. In response to the widely used Dollar-Cost Averaging (DCA) strategy, we use three modified Dollar-Cost Averaging approaches as the Return-based Dollar-Cost Averaging, the Z-score Dollar-Cost Averaging, and the LOHAS Staff Notation as comparisons. Taking the Yuanta Taiwan 50 ETF (ticker symbol: 0050) as target, covering the period from July 2008 to July 2023, we find that all three modified DCA strategies contribute higher annualized returns than the conventional DCA. The optimal parameter combination is the Return-Based Cost Averaging method without a double-investment limit. The LOHAS Staff Notation approach achieves the highest annualized return under a 4-year calculation period.

To verify the long-term robustness of these strategies, the study conducted a rolling 10-year return analysis. The empirical results show that these modified investment amount strategies have more than an 87.13% probability of outperforming conventional DCA in terms of annualized returns. This demonstrates the significant long-term profitability and strong robustness of the proposed models across different market conditions.

Keywords: *Modified Dollar-Cost Averaging, LOHAS Staff Notation Investment Method, Exchange-Traded Fund (ETF)*

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Introduction

Since the 1980s, the advancement of globalization and information technology has fueled rapid growth in emerging market economies. Stock markets then play an increasingly significant role in global capital allocation. Owing to their potential for higher returns and diversification benefits, emerging markets have attracted considerable international capital inflows. Harvey (1995) demonstrates that returns in emerging stock markets are predictable and that their long-term average returns exceed those of developed markets significantly, consequently offering investors greater profit. As one of the leading emerging economies, Taiwan stock market has experienced substantial expansion over the past two decades. Data from the Taiwan Stock Exchange show that the market capitalization of Taiwan has grown dramatically, underscoring Taiwan's rise as a major stock market in the Asia-Pacific region.

With the continued growth of Taiwan capital market in recent years, participation in stock investments has also steadily increased. The rising number of individual investors energize the financial market. However, this trend also underscores the urgent need to provide appropriate asset allocation guidance and risk management education for those individual investors. Therefore, the Dollar-Cost Averaging (DCA) strategy has become highly popular among retail investors due to its simplicity and ability to mitigate short-term market fluctuations. Nevertheless, Thorley (1995) points out that DCA strategy can reduce investment risk compared to lump-sum investing. However, the DCA may result in lower long-term returns.

In contrast to prior studies that mainly focus on developed markets, this study intends to develop a modified investment model that is specifically tailored to Taiwan stock market. The model is designed to offer practical and actionable strategies suitable for a broad range of investors. In pursuit of this objective, this study employs the following approaches. First, we conduct extensive long-term back-testing to empirically validate the model effectiveness. Second, we compare the proposed modified models with the conventional DCA approach, analyzing differences on both annualized returns and average holding costs bases. Finally, we assess performance robustness through rolling return analysis. Such robustness evaluation enables the examination of long-term investment outcomes across different long and short timing points, thereby reducing potential bias arising from extreme market timing conditions.

The primary objective of this study is to develop and validate a modified DCA model designed to help individual investors achieve higher long-term annualized returns while mitigating investment risk. The study aims to provide an accessible and practical investment decision-making framework that enables a broader range of investors to effectively apply investment strategies for sustained wealth accumulation. With the continuous inflow of capital into the financial market, the stock exchange is anticipated to realize higher liquidity, greater market efficiency, and a strengthened capacity for corporate financing, thereby fostering sustainable real economic development. This research not only supports wealth enhancement of individuals but also fosters the overall development, maturity, and international competitiveness of capital market.

This study proposes three modified DCA approaches to make comparison with conventional DCA. The Yuanta Taiwan 50 ETF (#0050), which is compiled by the Taiwan Stock Exchange Company and FTSE that comprise 50 of the most highly capitalized blue-chip stocks and representing nearly 70% of the Taiwanese market, are used as sample in the time frame of July 2008 to July 2023. We find the three modified DCA approaches performing better than the conventional DCA strategy. The advantage stands still when 10-year rolling return robustness check is applied, telling the result holds regardless of market conditions.

2. Literature review

2.1 ETF

The Exchange-Traded Fund (ETF) is an innovative investment tool designed to replicate the performance of a specific securities index. Its unique structure lies in the fact that the issuing company entrusts a basket of stocks to a custodian for management and divides the ownership into ETF units for public trading. Investors can freely buy and sell ETFs in the secondary market or convert ETF units back into the underlying index components. In recent years, the emergence of both thematic and strategic ETFs satisfies the needs of portfolio diversification.

The key advantage of ETFs is the trading flexibility. Investors can adjust positions in real time based on market conditions. Statman (1987) examines the relationship between the number of holdings and portfolio diversification, supporting the advantage of ETFs as a tool for achieving effective diversification. Since ETFs typically track specific indices, they can reduce the impact of individual stock volatility on the overall portfolio. Consequently, ETFs generally carry lower overall risk compared to single-stock investments.

As ETFs have become increasingly popular worldwide, both academia and practitioners have conducted extensive research on ETF investment strategies. Regarding the time-cost effect of ETFs, Atra and Mann (2001) and Leggio and Lien (2003) find that investing in ETFs through periodic fixed investment DCA method can effectively reduce investment costs compared with lump-sum investing. This is mainly because ETF prices exhibit certain seasonal fluctuations, and periodic investing helps smooth out cost variations.

In optimizing periodic ETF investment strategies, Dunham and Friesen (2012) and Lin and Xu (2016) propose modified adjusting investment amounts based on market indicators. Their findings demonstrate that such flexible, modified DCA strategies can significantly enhance returns while reducing costs, providing the motivation for this study. Furthermore, Bessembinder (2018) finds that in the U.S. stock market, only about 4% of listed firms account for the entire net wealth creation, a pattern observed across global markets. In the long run, only a small fraction of companies outperforms the risk-free rate. Consequently, many scholars recommend that non-professional investors use market-cap-weighted ETFs to achieve diversification. These instruments are particularly suitable for individual investors with limited capital and investment expertise.

2.2 Dollar-Cost Averaging and Modified Dollar-Cost Averaging

Maintaining rationality and self-discipline enables investors to achieve profits in both bull and bear markets. Further, caution, logical decision-making, and emotional restraint are likewise essential for attaining stable long-term investment returns. To help investors stay engaged through market fluctuations and ease worries about buying at peaks, they can invest in ETFs and apply either a DCA or modified DCA strategy over the long term.

2.2.1 Dollar-Cost Averaging

The DCA refers to an investment strategy in which investors purchase a target asset at fixed intervals with a predetermined amount of capital. The primary advantage of this approach lies in its ability to smooth investment costs over time and mitigate the risk associated with making a lump-sum investment at market peaks. Israelsen (1999) demonstrates that DCA can outperform lump-sum investing under conditions of low price volatility. Statman (1995) also argues that DCA reduces investors' anxiety regarding market fluctuations and helps prevent suboptimal investment decisions. Nevertheless, the effectiveness of DCA remains a subject of debate. Constantinides (1979) contends that DCA is most appropriate for investors who is unable to commit their entire capital at once. Although the DCA lowers the average cost of investment, it is not, in theory, an optimal strategy.

2.2.2 Modified Dollar-Cost Averaging

An obvious drawback of DCA is it ignores the market timing problem. A fixed dollar amount is invested at regular intervals, regardless the market is up or down. Some researchers proposed modified investment strategies that adjust contribution amounts based on market conditions, known as Modified DCA. The theoretical foundation of such modified approaches originates from the work of Poterba and Summers (1988) and Fama and French (1988), who identified a significant "mean reversion" effect in stock prices. Mean reversion refers to the tendency of asset prices, returns, or volatility to move back toward their long-term average after deviating from it. Specifically, prices that rise above their long-term mean typically experience a downward adjustment, whereas prices that fall below the mean tend to move upward. This behavior does not imply an immediate correction; rather, it reflects the statistical property that extreme values are generally temporary and do not persist over time. The predictability associated with such mean-reverting movements provides a theoretical basis for modified investment strategies that adjust contributions according to market conditions. By leveraging this characteristic, investors can systematically modify their investment amounts and potentially enhance long-term returns.

Richardson and Bagamery (2011) proposed a modified DCA model that adjusts the investment amount in each period according to past price movements. When the market declines, the contribution increases; when it rises, the contribution decreases. Their results showed that the modified DCA approach significantly improves investment performance compared with the conventional DCA method.

Similarly, Lin and Xu (2016) introduced a modified DCA strategy that adjusts investment amounts based on the standard deviation of past price fluctuations. Their empirical findings across U.S., Japanese, and European markets revealed that this modified adjustment approach consistently outperforms conventional DCA.

2.2.3 LOHAS Staff Notation Method

Dimitrios and Priestley (1999) observe mean reversion in Southeast Asian stock indices, suggesting that stock prices do not perfectly follow the random walk. Alexander and Peterson (2020) further discover that since ETFs often trade at persistent premiums or discounts relative to their net asset values (NAVs), they are subject to ongoing arbitrage forces, creating a self-correcting mean reversion process in ETF prices.

Based on mean reversion, Tseng (2007) proposed the Tseng's Tunnels (TCL). The TCL converts a stock index into its logarithmic form so that its long-term trend appears linear, as expressed in the following equation:

$$\boldsymbol{Log(Index) = a \cdot T + C} \quad (1)$$

Here, log(Index) denotes the logarithm of the index, T represents time measured in trading days, and both a and C are regression coefficients. According to this regression trend line, Tseng further designs five reference bands: Extremely Bullish Line (upper 95% confidence interval), Overly Bullish Line (upper 75%), Median Line (long-term trend), Overly Bearish Line (lower 75%), and Extremely Bearish Line (lower 95%).

Base on the TCL approach, Shiue and Tivo168 (2016, 2018) propose the LOHAS Staff Notation investment method. This method retains the idea of five reference bands from TCL but replaces the logarithmic transformation with actual price data. It constructs trend lines using moving averages over a selected time window. In addition, it introduces upper and lower bounds at one and two standard deviations above and below the trend line, respectively, to form five reference lines. The resulting pattern resembles a musical staff, hence the name Staff Notation. The LOHAS Staff Notation method suggests that when the stock price rises above the Overly Bullish Line, it indicates excessive optimism, suggesting that investors should gradually reduce their holdings. Conversely, when the price falls below the Overly Bearish Line, it signals a good buying opportunity and calls for increasing investment. Through this framework, investors can better utilize the mean-reversion behavior of prices and align with long-term market trends.

Shiue et al. (2017) applies the LOHAS Staff Notation model to ETFs across multiple markets, including the Vanguard Total Stock Market ETF (VTI), iShares MSCI ACWI (ACWI), iShares MSCI Russia ETF (ERUS), iShares MSCI Brazil ETF (EWZ), and Yuanta Taiwan 50 ETF (#0050), covering the period from January to July

2016. The study finds an average return of 26.75%, outperforming the S&P 500 Index by 4.46% during the same period. Wu (2018) employees the LOHAS Staff Notation model strategy to 58 Apple-related concept stocks and achieved an average return of 84%, significantly outperforming the broader market. Yang (2020) further examines the strategy using mutual funds and finds that the LOHAS Staff Notation model strategy generates higher returns than the conventional DCA approach.

Regarding the optimal observation period, Fama and French (1988) estimated that the half-life of mean reversion in stock prices is approximately three to five years. Similarly, Balvers et al. (2000) examine data from 18 major global markets and find a comparable mean reversion half-life. Shiue and Tivo168 (2016, 2018) also observed cyclical fluctuations in global equity markets, typically spanning three to four years for short cycles and seven to eight years for longer ones. They therefore recommended using half of a long cycle, approximately 3.5 years, as the ideal analysis period for the LOHAS Staff Notation model.

3. Methodology and Research Design

3.1 Research Framework

This study aims to evaluate whether the proposed modified Dollar-Cost Averaging investment strategy can deliver superior long-term performance compared with the conventional dollar-cost averaging (DCA) strategy. Following Shen (2022), we adopt the two modified DCA approaches: Return-based DCA method (RDCA) and the Z-score DCA method (ZDCA), as well as the LOHAS Staff Notation approach (LSN) of Shiue and Tivo168 (2016, 2018). This study evaluates three modified DCA approaches to assess whether they deliver better performance on Yuanta Taiwan 50 ETF compared to the conventional DCA strategy.

To assess the long-term applicability of each strategy, this study employs a ten-year rolling return analysis to examine whether their long-term performance consistently outperforms the conventional DCA method across different initial investment dates, thereby evaluating their robustness. Through a multi-dimensional comparison, including annualized returns, average cost, and robustness, we conduct an in-depth analysis of the differences between modified DCA strategies and the conventional DCA approach, with the aim of providing valuable insights for investors' decision-making.

3.2 Samples

This study selects ETFs rather than individual stocks as the research sample because ETFs offer higher pricing transparency, allowing their prices to accurately reflect the performance of the underlying index. This characteristic also facilitates a more realistic assessment of investment strategy performance. For the target ETF, we choose the Yuanta Taiwan Top 50 ETF, listed on the Taiwan Stock Exchange. As one of the most liquid and representative indices in Taiwan's capital market, #0050 appropriately reflects the overall movement of the Taiwanese stock market.

The sample data are obtained from the Taiwan Economic Journal (TEJ) database, using ETF data retrieved through TEJ. We collect daily adjusted closing prices from July 7, 2008, to July 5, 2023, covering a total of 15 years. Although #0050 was launched in June 2003, the LSN method requires five years of historical prices to construct the five-line chart used in its analysis. Therefore, to enable a realistic performance comparison, the study period begins in July 2008.

3.3 Research design

The scheduled investment date is the 5th day of each month. If the date falls on a non-trading day, the contribution is postponed to the next trading day. On each contribution date, it purchases the corresponding number of shares based on the adjusted closing price of that day. To more closely approximate the theoretical fair value, odd-lot purchases are allowed. During the investment period, it is assumed that the investor does not sell any holdings and instead retains all positions until fully liquidating them on July 5, 2023.

For performance measurement, this study assumes that all buy and sell transactions are executed successfully at the adjusted closing price, and no additional transaction costs are considered. This setup allows the inherent characteristics of each strategy to be more clearly reflected, providing a solid foundation for subsequent performance evaluation and comparative analysis.

In the investment strategy model of this study, M_t is a function that adjusts the investment amount for each period based on current market information. When M_t =1, indicating that no adjustment is made to the investment amount and the originally fixed contribution is maintained. That is equivalent to the DCA strategy. Throughout the entire research period, the fixed monthly investment amount for the DCA baseline is set at 10,000 TWD.

3.3.1 Return-Based Average Cost Method

The RDCA adjusts the investment amount each period according to the historical price movements of the underlying asset. In this study, we examine the performance of this method under different parameter settings in the empirical analysis. The calculation formula is defined as follows:

$$\boldsymbol{M_t = 1 - a \cdot r_t(k)} \tag{2}$$

In this method, r_t (k) represents the cumulative return of the underlying asset over the past k trading days prior to period t. The parameter a is a positive constant that determines the sensitivity of the investment adjustment to past price changes. When r_t (k) is positive, indicating that the asset price has recently increased, M_t becomes less than 1. In this case, compared with the DCA amount, the RDCA reduces the investment amount for that period.

Conversely, when r_t (k) is negative, indicating a recent price decline, M_t becomes greater than 1, leading to an increase in the investment amount. Reducing the purchase amount after price increases helps avoid buying at excessively high costs, whereas increasing the amount after price declines allows for more favorable accumulation.

In this strategy, the parameters k and a can be optimized as independent variables. A larger k reflects a longer price trend reference period, while a larger value a implies higher sensitivity to price movements. Different parameter combinations may produce optimal outcomes under different market conditions. For this modified DCA method, we consider historical returns over approximately one month, one quarter, half a year, and one year of trading days specifically. That is k = 20, 60, 120, or 250. For the constant multiplier, we consider a = 1, 5, 10, 15, or 20, resulting in 4×5=204 combinations.

3.3.2 Z-score Dollar Cost Averaging

The ZDCA adjusts the investment amount each period based on the deviation of the asset's current price from its historical mean, measured by the Z-score. Let P_t denote the adjusted closing price of the asset in period, μ_t (k) the arithmetic mean of the adjusted closing prices over the previous k trading days, and σ_t (k) the corresponding standard deviation. The parameter a is a positive constant that determines the sensitivity of investment adjustments to the degree of price deviation. The Z-score is computed as:

$$\boldsymbol{Z-score = \frac{P_t - \mu_t(k)}{\sigma_t(k)}} \tag{3}$$

The Z-score measures the standardized deviation of the current price relative to the recent historical price sample. A positive Z-score indicates that the current price is above the recent average and M_t becomes less than 1, leading to a reduction in the investment amount for that period. Conversely, a negative Z-score indicates that the price is below the recent mean, M_t becomes greater than 1, thus increasing the investment amount. By relying on a standardized measure of price deviation, the ZDCA Method can automatically determine whether the current price is relatively high or low and adjust the investment amount accordingly.

Similar to the RDCA, the parameters k and a in the ZDCA can also be optimized as independent variables to identify the best parameter combinations under different market conditions. Equation (4) shows the M_t of ZDCA model.

$$\boldsymbol{M_t = 1 - a \cdot \frac{P_t(k) - \mu_t(k)}{\sigma_t(k)}} \tag{4}$$

3.3.3 Short-sell Prohibition and Limitation on Maximum Investment Amount

In order to make the indicator more aligned with the actual conditions faced by investors, the key parameter Mt in the indicator is restricted to vary within a certain range, thereby enhancing its practicality. In this study, we adopt the method proposed by Shen (2022) to better capture the real market conditions. Our modified parameter, M'_t, is defined as:

$$\boldsymbol{M'_t} = \mathbf{max}(\mathbf{0}, \mathbf{min}(\mathbf{2} \cdot \boldsymbol{M_t}, \boldsymbol{M_t})) \tag{5}$$

We set two constraints on the indicator values. First, short selling is not allowed, so the minimum value of the indicator is set to 0. Second, the maximum value of the indicator is capped at twice the original investment amount. This approach makes the indicator calculations more reflective of actual market conditions.

3.3.4 Short-sell Prohibition with no Limitation on Investment Amount

The previously mentioned limit of twice the maximum investment amount was intended to reflect the common capital constraints faced by retail investors, while prohibiting short selling was meant to preserve the original purpose of DCA. In this section, we still set the minimum indicator value to 0 to prohibit short selling, but no upper limit is imposed on the maximum investment amount. Both calculation methods for the indicators are designed to represent reasonable adjustments based on actual market conditions, thereby enhancing the reliability and practicality of the study. Accordingly, the new indicator, M''_t, can be expressed as follows:

$$\boldsymbol{M''_t} = \boldsymbol{max}(\mathbf{0}, \boldsymbol{M_t}) \tag{6}$$

Based on the principles of avoiding short selling in periodic asset investment and the spirit of increasing or decreasing positions under mean-reversion modified investment, we apply both setting on M_t (M'_t and M''_t) in the case of RDCA and ZDCA.

3.3.5 LOHAS Staff Notation

This study also applies the LSN of Shiue and Tivo168 (2016), aiming to explore the optimal evaluation period and investment amount. Obviously, we need to use historical data to construct the staff notation, the five lines channel that helps investors to make increase or decrease investment amount decision. To examine whether different choices of the evaluation period affect returns, we follow the findings of Fama & French (1988) and Balvers & Gilliland (2000) to have 3-, 3.5-, 4-, 4.5-, and 5-year evaluation period. Finally, five different types of LSN model are constructed.

n the LSN approach, the trend line serves as the central line among the five lines, and the standard deviation defines the spacing between them. When the asset price rises above the central line, the investment amount should be gradually reduced; when the price falls below it, the investment amount should be increased. In other words, the investment amount is determined by the asset price’s position relative to the LSN intervals on the deduction date. The deduction amounts we use are presented in Table 1.

This study designs three plans, all of which follow the LSN investment rules. The difference among them lies in the magnitude of the increases and decreases in investment amounts. In Plan 1, the adjustment is 1,000 (10% of

Table 1

The investment amount in LSN approach

This table reports the investment amount of the LSN approach respecting to the position that the asset price is located in the Staff Notation. The investment amount will be increased (decreased) when the current value is lower (higher).

Position within LSN Interval	Investment Amount		
	Plan 1	Plan 2	Plan 3
Above +2 SD	7,000	4,000	1,000
+1 SD to +2 SD	8,000	6,000	4,000
+1 SD to trend line	9,000	8,000	7,000
Trend line to -1 SD	11,000	12,000	13,000
-1 SD to -2 SD	12,000	14,000	16,000
Below -2 SD	13,000	16,000	19,000

Note: SD=Standard Deviation

the scheduled investment amount), while in Plans 2 and 3, the adjustments are amplified as 2,000 (20%) and 3,000 (30%), respectively.

3.4 Performance measurement

This study evaluates the performance of the four investment strategies using two metrics: annualized return and average cost.

3.4.1 Annualized Return

The annualized return was calculated as follows. The 5th day of each month was designated as the purchase date, and the 5th day of the maturity month as the settlement date. Investments were made periodically and held until maturity. The final annualized return for each investment was computed based on the purchase price and the price at maturity. Let the investment amounts each month be m_1, $m_2 \ldots m_t$, with a total of t investment periods. Then, the total invested amount, or total investment cost, is given by:

$$\boldsymbol{m_1 + m_2 + \cdots + m_t = \sum_{i=1}^{t} m_i} \tag{7}$$

Let v_i denotes the closing price on the purchase day, and mi the investment amount for that period. The number of shares held for that month, u_i, is then calculated as:

$$\boldsymbol{u_i = \frac{m_i}{v_i}} \tag{8}$$

After a total of t investment periods, the total number of shares held is:

$$\boldsymbol{u_1 + u_2 + \cdots + u_t = \sum_{i=1}^{t} \frac{m_i}{v_i}} \tag{9}$$

The total amount received upon maturity, M_t, is equal to the adjusted closing price at maturity, v_t, multiplied by the total number of shares held:

$$\boldsymbol{M_t = v_t \cdot \sum_{i=1}^{t} \frac{m_i}{v_i}} \tag{10}$$

Accordingly, the annualized return, R, satisfies the following equation.

$$\boldsymbol{\frac{M_t}{(1+R)^t} + \sum_{i=0}^{t-1} \frac{-m_i}{(1+R)^i} = 0} \tag{11}$$

3.4.2 Average Cost

The average cost (AC) equals the total amount received from selling at maturity M_t divided by the total number of units (shares) held.

$$\boldsymbol{AC = \frac{M_t}{\sum_{i=1}^{t} \frac{m_i}{v_i}}} \tag{12}$$

4. Empirical Result and Analysis

4.1 RDCA and ZDCA with Maximum Double-Investment Limit

Following the framework of Shen (2022), the increase in the investment amount for each period is restricted to no more than twice the originally planned amount (10,000 TWD), and short selling is not allowed. The results show that, compared with the conventional DCA, all parameter combinations in Tables 2 and 3 using the RDCA method and the ZDCA method yield annualized returns higher than those of the conventional DCA. This indicates that applying the RDCA method and the ZDCA to the ETF #0050 can outperform the conventional DCA strategy.

According to Table 2, the annualized returns generated by the RDCA strategy outperform the conventional DCA approach across all parameter combinations, providing preliminary evidence that modified approach can enhance long-term investment performance. In particular, when the weight parameter a=20 and the reference period k=250 days, the annualized return of our target asset (#0050) reaches 12.45%, which is 0.68% higher than the conventional strategy.

The analysis of variations in k reveals that the RDCA method exhibits differing levels of sensitivity to the length of the reference period. For #0050, the annualized returns computed using this method show a positive correlation with k. Regarding the relationship between the annualized return and a when k is fixed, we find that the annualized return of #0050 increases steadily as a rises.

Table 2

The performance of applying conventional DCA and RDCA methods

This table reports the results applying conventional DCA and RDCA methods on the investment of Yuanta Taiwan Top 50 ETF (#0050) in the time frame of July 7, 2008, to July 5, 2023. When using the RDCA, we included a setting with and without the double investment limit to increase its flexibility. Also, we use different parameter settings on both k and a. The k is the time length of observations, given from 20 to 250 days. Whereas the a is the degree of sensitivity of price movement given from 1 to 20.

Method and Parameters	Total cost	Total value	Annualized Return	Average Cost	Method and Parameters	Total cost	Total value	Annualized Return	Average Cost
Conventional DCA	1,800,000	4,668,234	11.77%	49.71	Conventional DCA	1,800,000	4,668,234	11.77%	49.71
RDCA	**With** double investment amount restriction				RDCA	**Without** double investment amount restriction			
k=20, a=1	1,786,937	4,643,512	11.78%	49.61	k=20, a=1	1,786,937	4,643,512	11.78%	49.61
k=60, a=1	1,753,620	4,595,587	11.82%	49.19	k=60, a=1	1,753,620	4,595,587	11.82%	49.19
k=120, a=1	1,703,830	4,509,574	11.91%	48.71	k=120, a=1	1,703,830	4,509,574	11.91%	48.71
k=250, a=1	1,619,669	4,390,456	11.97%	47.56	k=250, a=1	1,619,669	4,390,456	11.97%	47.56
k=20, a=5	1,734,683	4,544,621	11.80%	49.21	k=20, a=5	1,734,683	4,544,621	11.80%	49.21
k=60, a=5	1,580,010	4,312,666	11.97%	47.23	k=60, a=5	1,593,221	4,396,079	12.01%	46.72
k=120, a=5	1,392,787	3,922,064	12.26%	45.78	k=120, a=5	1,443,006	4,223,967	12.35%	44.04
k=250, a=5	1,200,246	3,610,676	12.31%	42.85	k=250, a=5	1,280,183	4,071,544	12.42%	40.53
k=20, a=10	1,672,768	4,436,910	11.82%	48.60	k=20, a=10	1,689,002	4,488,166	11.82%	48.51
k=60, a=10	1,414,443	3,929,737	12.09%	46.40	k=60, a=10	1,524,388	4,432,342	12.17%	44.34
k=120, a=10	1,225,079	3,535,239	12.35%	44.67	k=120, a=10	1,449,839	4,640,560	12.57%	40.28
k=250, a=10	1,120,068	3,374,062	12.42%	42.80	k=250, a=10	1,469,281	5,046,532	12.55%	37.53
k=20, a=15	1,609,698	4,285,257	11.85%	48.43	k=20, a=15	1,675,003	4,516,623	11.86%	47.81
k=60, a=15	1,331,770	3,730,363	12.11%	46.02	k=60, a=15	1,595,978	4,840,442	12.23%	42.51
k=120, a=15	1,145,271	3,338,394	12.40%	44.23	k=120, a=15	1,601,247	5,408,710	12.68%	38.17
k=250, a=15	1,111,029	3,356,984	12.43%	42.67	k=250, a=15	1,809,464	6,454,832	12.57%	36.14
k=20, a=20	1,559,346	4,169,822	11.88%	48.21	k=20, a=20	1,692,584	4,625,607	11.89%	47.17
k=60, a=20	1,279,229	3,614,624	12.11%	45.62	k=60, a=20	1,723,271	5,401,222	12.27%	41.13
k=120, a=20	1,108,526	3,250,497	12.43%	43.97	k=120, a=20	1,814,642	6,337,447	12.74%	36.91
k=250, a=20	1,107,422	3,350,222	12.45%	42.61	k=250, a=20	2,175,897	7,924,724	12.58%	35.40

In Table 3, the ZDCA method likewise delivers annualized returns that outperform the conventional DCA strategy across all parameter combinations, further confirming the effectiveness of dynamic adjusting investment amounts. In particular, when the parameters are set to a=10 and the reference period k=250 days, the annualized return of #0050 reaches 12.5%, which is 0.73% higher than the conventional strategy, highlighting the profit potential of the ZDCA method. We find that the ZDCA strategy is not highly sensitive to changes in the parameter a; the annualized return is almost unaffected by variations in a, indicating that the reference period k plays the dominant role. As a result, changes in a contribute little to the final return, a characteristic that distinguishes this method from the RDCA approach. Moreover, by examining changes in k, we observe that the annualized return of #0050 shows a clear upward trend as k increases, with this positive relationship becoming particularly evident once k exceeds 60 days.

Table 3

The performance of applying conventional DCA and ZDCA methods

This table reports the results applying conventional DCA and ZDCA methods on the investment of Yuanta Taiwan Top 50 ETF (#0050) in the time frame of July 7, 2008, to July 5, 2023. When using the RDCA method, we included a setting with and without the double investment limit to increase its flexibility. Also, we use different parameter settings on both k and a. The k is the time length of observations, given from 20 to 250 days. Whereas the a is the degree of sensitivity of price movement given from 1 to 20.

Method and Parameters	Total cost	Total value	Annualized Return	Average Cost	Method and Parameters	Total cost	Total value	Annualized Return	Average Cost
Conventional DCA	1,800,000	4,668,234	11.77%	49.71	Conventional DCA	1,800,000	4,668,234	11.77%	49.71
ZDCA	With double investment amount restriction				ZDCA	Without double investment amount restriction			
k=20, a=1	1,363,798	3,661,855	11.95%	48.01	k=20, a=1	1,810,649	4,905,179	11.90%	47.59
k=60, a=1	1,249,604	3,441,430	12.08%	46.81	k=60, a=1	1,507,375	4,230,242	11.97%	45.94
k=120, a=1	1,124,564	3,268,219	12.25%	44.36	k=120, a=1	1,351,807	3,995,166	12.15%	43.62
k=250, a=1	1,065,361	3,208,460	12.42%	42.81	k=250, a=1	1,304,085	4,020,447	12.36%	41.82
k=20, a=5	1,322,209	3,498,668	12.08%	48.72	k=20, a=5	5,405,363	14,788,181	11.91%	47.12
k=60, a=5	1,206,618	3,345,931	12.09%	46.49	k=60, a=5	4,227,087	12,231,502	11.91%	44.55
k=120, a=5	1,091,651	3,278,986	12.23%	42.92	k=120, a=5	3,782,616	11,604,852	12.06%	42.02
k=250, a=5	1,029,964	3,128,650	12.49%	42.44	k=250, a=5	3,722,621	11,967,053	12.36%	40.10
k=20, a=10	1,315,542	3,468,016	12.09%	48.90	k=20, a=10	10,082,390	27,632,628	11.90%	47.04
k=60, a=10	1,204,006	3,330,042	12.09%	46.61	k=60, a=10	7,801,030	22,660,073	11.90%	44.38
k=120, a=10	1,093,044	3,287,574	12.23%	42.86	k=120, a=10	6,986,612	21,498,643	12.04%	41.90
k=250, a=10	1,025,439	3,114,460	12.50%	42.45	k=250, a=10	6,895,124	22,283,636	12.35%	39.89
k=20, a=15	1,311,983	3,456,265	12.09%	48.94	k=20, a=15	14,770,711	40,513,804	11.90%	47.00
k=60, a=15	1,197,403	3,307,238	12.09%	46.68	k=60, a=15	11,377,940	33,097,940	11.89%	44.32
k=120, a=15	1,095,536	3,294,076	12.23%	42.87	k=120, a=15	10,195,887	31,402,428	12.04%	41.86
k=250, a=15	1,028,159	3,125,524	12.49%	42.41	k=250, a=15	10,077,687	32,632,138	12.34%	39.81
k=20, a=20	1,307,742	3,444,381	12.09%	48.95	k=20, a=20	19,461,484	53,402,834	11.90%	46.98
k=60, a=20	1,192,047	3,289,494	12.09%	46.72	k=60, a=20	14,958,696	43,547,786	11.89%	44.28
k=120, a=20	1,100,714	3,305,802	12.23%	42.92	k=120, a=20	13,407,849	41,311,437	12.03%	41.84
k=250, a=20	1,028,101	3,126,944	12.49%	42.39	k=250, a=20	13,260,249	42,980,640	12.34%	39.77

We evaluate the performance of two modified investment adjustment strategies—the RDCA method and the ZDCA method—when applied to the ETF #0050. The results indicate that regardless of whether the RDCA or ZDCA method is used, the annualized returns for all parameter combinations outperform those of the conventional DCA approach. We also observe that for both strategies, increases in the reference period k and the weight parameter a lead to reductions in the average holding cost, reflecting that dynamic adjusting investment amounts helps lower the portfolio's cost basis.

4.2 RDCA and ZDCA without Maximum Double-Investment Limit

To further uncover the potential benefits of the RDCA and the ZDCA methods, this section removes the constraint on the maximum investment amount. When the computed value of Mt exceeds 2, the investment amount for that period is adjusted in accordance with its actual magnitude, thereby allowing allocations to surpass twice the originally planned amount. The primary motivation for lifting this upper bound is to enable the strategies to more fully exploit investment opportunities that arise during periods of extreme market conditions. When the price of the underlying asset experiences a substantial decline, the value of Mt may increase sharply, indicating that a significant increase in investment during that period is warranted. Imposing a twofold cap would hinder the strategy from fully realizing this objective. Although removing the investment ceiling may increase the capital deployed in certain periods, it allows investors to accumulate a larger number of shares at relatively depressed price levels. From a long-term perspective, this facilitates a reduction in the average cost of holdings and ultimately enhances the annualized return of the strategy.

For making comparison, we report the results on the right hand sigh of Table 2. When there is no upper limit on the investment amount, all parameter combinations of the average-cost strategy yield annualized returns that outperform the conventional DCA strategy, and surpass the results observed under scenarios with an investment cap. We find that, under the average-cost strategy without an upper investment limit, the optimal parameter combination for #0050 occurs at a=20 and k=120, delivering an annualized return of 12.74%, which is 0.31% higher than the scenario with a cap. Levy (1967) and Poterba & Summers (1988) suggest that tracking stock price trends over a 120–150-day horizon is more appropriate. Our findings likewise confirm that moderately referencing medium- to long-term price trends and assigning them appropriate weights can help enhance the annualized return of a variable-amount investment strategy.

Regarding average cost, the findings of this study show that removing the upper limit of twice the investment amount can indeed further reduce the portfolio's average holding cost. However, this reduction in average cost does not translate into a significant improvement in annualized returns. The potential reasons behind this phenomenon merit continued attention and deeper investigation by future researchers. After all, the ultimate goal of an investment strategy is not merely to lower the average cost, but more importantly, to generate greater long-term returns for investors.

In summary, the findings of this section reveal that under the RDCA method and the ZDCA method without an upper investment limit, different parameter combinations exert varying effects on annualized returns. This insight helps us further refine parameter settings to maximize the potential of modifiedally adjusting investment amounts, thereby achieving more desirable investment outcomes.

4.3 LSN

We adopt the LSN strategy proposed by Shiue and Tivo168 (2016). According to the empirical results presented in Table 4, the annualized returns achieved by applying the strategy to the ETF #0050 are consistently higher than those of the conventional DCA method. This finding provides preliminary evidence supporting the superiority of the strategy compared with conventional DCA.

Regarding the optimal investment period of the LSN strategy, this study finds that setting the investment period to four years yields the highest annualized return. We can see the LSN Plan 3 attains an annualized return of 12.21%, outperforming conventional DCA by 0.44%. With respect to the adjustment range of investment amounts, we observe that moderately increasing the investment amount in the lower-bound trend zone while

Table 4

The performance of LSN

This table reports the results applying conventional DCA and LSN methods on the investment of Yuanta Taiwan Top 50 ETF (#0050) in the time frame of July 7, 2008, to July 5, 2023.

Method		Estimation period (year)	Total Cost	Total Value	Annualized Return	Average Cost
Conventional DCA			1,800,000	4,668,234	11.77%	49.71
LSN		3	1,787,000	4,693,917	11.89%	49.08
	Plan 1	3.5	1,785,000	4,713,522	11.91%	48.82
		4	1,778,000	4,711,280	11.92%	48.65
		4.5	1,780,000	4,718,559	11.91%	48.63
		5	1,762,000	4,688,860	11.90%	48.45
		3	1,774,000	4,719,600	12.02%	48.46
	Plan 2	3.5	1,770,000	4,758,809	12.04%	47.95
		4	1,756,000	4,754,325	12.07%	47.62
		4.5	1,760,000	4,768,884	12.05%	47.58
		5	1,724,000	4,709,486	12.03%	47.19
		3	1,761,000	4,745,282	12.14%	47.84
	Plan 3	3.5	1,755,000	4,804,097	12.18%	47.10
		4	1,734,000	4,797,371	12.21%	46.60
		4.5	1,740,000	4,819,209	12.18%	46.55
		5	1,686,000	4,730,112	12.15%	45.95

reducing it in the upper-bound zone significantly enhances annualized returns. Furthermore, when the gap between the investment amounts allocated to the upper and lower trend zones is widened even more, the annualized return improves again. This result validates the fundamental principle of the LSN strategy: ‘increase investment at lower price levels and reduce investment at higher price levels.

In examining the average investment cost, the results show an inverse relationship between average cost and the investment period. Similar to the investment-adjustment rule, increasing investment in the lower-bound trend zone while decreasing it in the upper-bound zone effectively lowers the overall average investment cost. Moreover, further widening the investment gap between the two zones leads to an additional reduction in average cost.

4.4 Comparison of three modified DCA strategies

Across the three variable-amount investment strategies examined in this study, all applications to the ETF #0050 produce annualized returns that outperform the conventional DCA method. Table 5 summarizes the maximum annualized returns achieved by each of the three strategies. We recommend that investors adopt the RDCA strategy without the two-times investment cap, and set the parameters to k=250 and a=20. Under this configuration, the strategy yields an annualized return of 12.74%, which is 0.97% higher than that of the conventional DCA approach.

Table 5

The best performance of each method

This table presents the best performance and the relative settings of the four approaches obtained from this study.

Method	Conventional DCA	RDCA	ZDCA	LSN
Max Return	11.77%	12.74%	12.50%	12.21%
Parameters		k=250, a=20	k=250, a=10	
Setting		Without two-times investment amount restriction	With two-times investment amount restriction	Plan 3 with 4-year estimation

4.5 Robustness Analysis

To verify the robustness of the various variable-amount investment strategies proposed in this study under different market conditions, we further employ a rolling 10-year return analysis to assess whether each strategy can consistently outperform the conventional DCA method over the long term. Specifically, the sample period is divided into multiple consecutive 10-year sub-periods, and the annualized return of each strategy is calculated within each sub-period. The results of all sub-periods are then aggregated and averaged. In total, the full sample can be divided into 61 rolling 10-year windows.

Table 6

Robustness check of RDCA and ZDCA performance comparing to conventional DCA

This table reports the odds and excess return of RDCA and ZDCA comparing to conventional DCA in the robustness check under different parameter setting.

RDCA			ZDCA		
Parameters	Odds	Excess return	Parameters	Odds	Excess return
(k=20,a=1)	93.44%	0.01%	(k=20,a=1)	88.52%	0.29%
(k=60,a=1)	90.16%	0.04%	(k=60,a=1)	90.16%	0.51%
(k=120,a=1)	88.52%	0.08%	(k=120,a=1)	91.80%	0.82%
(k=250,a=1)	93.44%	0.17%	(k=250,a=1)	93.44%	1.19%
(k=20,a=5)	93.44%	0.05%	(k=20,a=5)	85.25%	0.35%
(k=60,a=5)	91.80%	0.22%	(k=60,a=5)	90.16%	0.59%
(k=120,a=5)	90.16%	0.47%	(k=120,a=5)	88.52%	0.93%
(k=250,a=5)	90.16%	0.86%	(k=250,a=5)	91.80%	1.41%
(k=20,a=10)	78.69%	0.04%	(k=20,a=10)	81.97%	0.34%
(k=60,a=10)	98.36%	0.47%	(k=60,a=10)	88.52%	0.59%
(k=120,a=10)	93.44%	0.80%	(k=120,a=10)	88.52%	0.95%
(k=250,a=10)	91.80%	1.27%	(k=250,a=10)	90.16%	1.43%
(k=20,a=15)	98.36%	0.18%	(k=20,a=15)	80.33%	0.33%
(k=60,a=15)	98.36%	0.62%	(k=60,a=15)	88.52%	0.59%
(k=120,a=15)	96.72%	1.04%	(k=120,a=15)	88.52%	0.95%
(k=250,a=15)	86.89%	1.34%	(k=250,a=15)	90.16%	1.44%
(k=20,a=20)	100.00%	0.27%	(k=20,a=20)	88.52%	0.29%
(k=60,a=20)	98.36%	0.73%	(k=60,a=20)	88.52%	0.59%
(k=120,a=20)	98.36%	1.18%	(k=120,a=20)	86.89%	0.82%
(k=250,a=20)	86.89%	1.36%	(k=250,a=20)	90.16%	1.44%
Average	92.87%	0.56%	Average	88.52%	0.79%

We compare the performance of the RDCA strategy, the ZDCA strategy, and the LSN strategy without the two-times investment cap against the conventional DCA method across these 61 rolling periods. The results are summarized in Tables 6 and 7.

As shown in Tables 6 and 7, the RDCA, ZDCA, and LSN methods outperform the conventional DCA method in 92.87%, 88.52%, and 100% of the 61 rolling periods, respectively. The corresponding average excess annualized returns are 0.56%, 0.79%, and 0.37%. Moreover, as the parameter values of k and a increase, the advantages of

Table 7

Robustness check on the performance of LSN comparing to conventional DCA

This table reports the odds and excess return of LSN comparing to conventional DCA in the robustness check by three different plan setting.

Method		Estimation period	Odds	Excess return
LSN		3	100%	0.14%
	Plan 1	3.5	100%	0.17%
		4	100%	0.19%
		4.5	100%	0.19%
		5	100%	0.18%
		3	100%	0.29%
	Plan 2	3.5	100%	0.36%
		4	100%	0.40%
		4.5	100%	0.40%
		5	100%	0.38%
		3	100%	0.46%
	Plan 3	3.5	100%	0.56%
		4	100%	0.62%
		4.5	100%	0.61%
		5	100%	0.58%
	Average		100%	0.37%

both the RDCA strategy and the ZDCA strategy over the conventional DCA method become even more pronounced.

5. Conclusion and Suggestion

This study examines the performance differences between three modified investment-amount adjustment strategies—the return-based average-cost method, the Z-score average-cost method, and the LOHAS Staff Notation Strategy—and the conventional dollar-cost averaging method in the Taiwan stock market. The results confirm that these modified strategies are capable of achieving higher annualized returns than the conventional DCA approach in most cases, demonstrating the significant advantages of adjusting investment amounts modifiedally.

Taking the ETF #0050, which represents the top 50 companies in the Taiwan stock market by market capitalization, as sample, we find the highest annualized return is achieved under the return-based average-cost strategy without the two-times investment cap, using the parameter setting of k=250 (longer evaluation period) and a=20 (greater sensitivity to price movements). The findings indicate that moderately referencing medium- to long-term price trends and assigning them a higher weight can further enhance the performance advantage of variable-amount investment strategies relative to fixed-amount approaches.

On the other hand, this study finds that the LOHAS Staff Notation Strategy also performs exceptionally well. When a four-year investment period is adopted, and the investment amount is moderately increased in the lower-bound trend zone while decreased in the upper-bound zone, not only is the annualized return significantly improved, but the overall average investment cost is also effectively reduced. This finding provides clear guidance on parameter adjustments for the practical implementation of the LOHAS Staff Notation Strategy.

Finally, this study provides Taiwanese investors with three modified investment-amount adjustment strategies that can help achieve long-term asset growth. It is expected that through further research and practical application, the use of these strategies offers investors substantial improvements in returns.

Reference

1 Alexander, G. J. & Peterson, M. A. 2020. The Pricing of Exchange Traded Funds and the Roles of Primary and Secondary Market Participants. *Quarterly Journal of Finance*, 10(3): 1–27.

2 Anson, M. J., Fabozzi, F. J., & Jones, F. J. 2010. The handbook of traditional and alternative investment vehicles: investment characteristics and strategies. John Wiley & Sons.

3 Atra, R. J. & Mann, T. L. 2001. Dollar-cost averaging and seasonality: Some international evidence. *Journal of Financial Planning*, 14(7): 98–103.

4 Balvers, R., Wu, Y. & Gilliland, E. 2000. Mean reversion across national stock markets and parametric contrarian investment strategies. *The Journal of Finance*, 55(2): 745–772.

5 Bessembinder, H. 2018. Do stocks outperform treasury bills? *Journal of Financial Economics*, 129(3): 440-457.

6 Constantinides, G. M. 1979. A note on the suboptimality of dollar-cost averaging as an investment policy. *Journal of Financial and Quantitative Analysis*, 14(2): 443–450.

7 Dimitrios, M. & Priestley, R. 1999. Mean reversion in Southeast Asian stock markets. *Journal of Empirical Finance*, 6: 355–384.

8 Dunham, L.M. & Friesen, G. C. 2012. Building a better mousetrap：Enhanced dollar cost averaging. Journal of Wealth Management, 15 (1): 41–50.

9 Fama, E. F. & French, K. R. 1988. Permanent and temporary components of stock prices. *Journal of Political Economy*, 96(2): 246–273.

10 Fama, E. F. 1965. The behavior of stock-market prices. *The Journal of Business*, 38(1): 34–105.

11 Harvey, C. R. 1995. Predictable risk and returns in emerging markets. *The Review of Financial Studies*, 8(3): 773–816.

12 Israelsen, C. L. 1999. Lump Sums Take Their Lumps: Contrary to popular opinion, lump- sum investing doesn't always result in superior returns over dollar-cost averaging. *Financial Planning*, January: 51–56.

13 Leggio, K. B. & Lien, D. 2003. An empirical examination of the effectiveness of dollar cost averaging using downside risk performance measures. *Journal of Economics and Finance*, 27(2): 211–223.

14 Levy, R. A. 1967. Relative strength as a criterion for investment selection. *The Journal of Finance*, 22(4): 595–610.。

15 Lin, E. & Xu, H. 2016. Modified Dollar Cost Averaging Investment Strategy: Evidence from Major Developed International Stock Markets. *Journal of Finance Issues*, 15 (1):20–30.

16 Meir, S. 1995. A behavioral framework for dollar-cost averaging. *Journal of Portfolio Management*, 22(1): 70–78.

17 Patel, J., Shah, S., Thakkar, P. & Kotecha, K. 2015. Predicting stock market index using fusion of machine learning techniques. *Expert Systems with Applications*, 42(4): 2162–2172.

18 Poterba, J. M., & Summers, L. H. 1988. Mean reversion in stock prices： Evidence and implications. *Journal of Financial Economics*, 22(1): 27–59.

19 Richardson, G. M. & Bagamery, B. D. 2011. Dynamic Dollar-Cost Averaging. *Journal of Financial Service Professionals*, 65(2): 56–60.

20 Shen, J. 2022. A General Framework for Enhancing the Return of Dollar Cost Averaging Investing. Available at SSRN 4235766.

21 Shiue, W. & Tivo168. 2016. The Staff Notation Investment Technique: Automatically Identify High and Low Prices, Earn 20% Annually Without Constant Monitoring. Taipei: BERICH MEDIA CORP. (in Chinese).

22 Shiue, W. & Tivo168. 2018. Advanced Version of the Staff Notation Investment Technique: Utilize the Staff Notation to Profit from Both Ups and Downs. Taipei: Kingway Publishing (in Chinese).

23 Shiue, W., Chen, H., Liang, W., Chou, A. Y. H. & Tseng, F. S. C. 2017. A Five Line Stave Decision Model for Constructing a Big Trend Decision Support System for ETF Mutual Fund Investment. *International Journal of Engineering Research*, 6(2): 61–65.

24 Statman, M. 1987. How many stocks make a diversified portfolio? *Journal of Financial and Quantitative Analysis*, 22(3): 353–363.

25 Statman, M. 1995. A Behavioral Framework for Dollar-Cost Averaging. *The Journal of Portfolio Management*, 22(1): 70-78.

26 Thorley, S. R. 1995. The time-diversification controversy. *Financial Analysts Journal*, 51(3): 68–76.

27 Tseng, Y. 2007. Tseng's Investment Dictionary. HK: Enrich Culture (in Chinese).

28 Yang, P. 2020. A Study of the Periodical Investment Plan by Using Staff Notation Investment Method. National Kaohsiung University of Science and Technology. Kaohsiung, Taiwan. Master’s thesis.