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投資共同基金方法之比較：定期定額法與單筆總額法

A Comparison of Dollar-Cost Averaging with Lump-Sum Investing for Mutual Funds

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摘要：本文比較兩種投資共同基金方法—定期定額法與單筆總額法—之績效優劣。過去實證研究大多發現單筆投資的績效優於定期定額法，但實務界與投資學書籍卻極力推薦後者。本文認爲過去研究多只考慮短期投資 (一年以內)，及樣本期間始至股市初期發展階段可能是影響實證結果的關鍵因素，爰以 2000/1~2006/5 台灣的開放式股票型基金爲樣本，比較兩種方法產生的短、長期 (包括一至五年) 原始和風險調整後的年化報酬率 (每種再分爲單利與複利) 之大小，並以數種期間起點的台股指數作穩健性檢定的樣本，統計方法是成對樣本 T 檢定與無母數檢定。實證發現，長期投資下，定期定額法比單筆總額法有較高的報酬和較低的風險，且隨著投資時間延長，前者的風險愈低、報酬愈高，這可能與淨值波動性較高有關。再者，納入較早期的股市資料確會提高總額法的績效，表示價格走勢是影響兩方法比較結果的因素之一，但即使如此，採定期定額法時，若將尚未投入之資金先投資在無風險資產，則當無風險利率愈低，單筆法可能稍優於定期定額法，但當無風險報酬增加，即使是短期投資，定期定額即優於單筆投資。

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關鍵詞：定期定額法、單筆總額法、年化報酬率、淨資產價值、開放式股票型基金

Abstract: This paper empirically compares the performance between Dollar-Cost Averaging (DCA) and Lump-Sum (LS) strategies in mutual fund investment. Most previous empirical studies find LS's performance surpass DCA's; however, the DCA strategy is advocated by many practitioners and long recommended by investment textbooks. This paper conjectures that only short-term investments (short than one year) examined by precedent articles and the simulating horizons containing the early time of stock market development might be the critical factors impacting their empirical results. In this paper, taking open-end equity funds traded in Taiwan from January 2000 to May 2006 as a sample, both the original and risk-adjusted annualized returns, where simple and compounded returns are calculated for each, across short- and long-term (1 - 5 year horizons) investments by DCA and LS are separately compared using paired-sample t- and nonparametric tests. Also, various beginning times for investing into Taiwan stock index are employed to perform the robustness check. The findings are that DCA possesses higher mean-variance efficiency than LS strategy in the long run. Adopting a DCA policy, the longer the averaging time, the greater the risk declines and terminal wealth increases; the reason may be that the funds' net asset values exhibit relatively higher volatility. Moreover, using the early-era stock prices enhances the LS's performance, revealing the price sequence may be a critical factor. Though the lower risk-free return, where the total amount is initially invested in this return and then gradually shifted to mutual funds in equal monthly installments by DCA, probably decreases DCA's performance and leads to LS slightly beating DCA, as that return boosts, DCA will outperform LS even if in the short term.

***Keywords*:** Dollar-Cost Averaging, Lump-Sum Investing, Annualized Return, Net Asset Value, Open-End Equity Funds

1. Introduction

Mutual funds are relatively popular financial instruments for individual investors now. They enable investors to pool their money and place it under professional investment management. The collective funds are invested systematically into other financial instruments to generate a portfolio. The portfolio manager or management team trades the funds' underlying securities, realizing a gain or loss, and collects the dividend or interest income. The investment proceeds are then passed along to the individual investors. Since mutual funds have the advantages of large fund magnitude, diversified risk and professional management, personal investors that have little money or insufficient time to manage finances particularly like this method. Both the magnitude and number of mutual funds have been rapidly increasing in the past couple of years.

Investing methods for mutual funds' investors primarily include Lump-Sum (hereafter known as LS) and Dollar-Cost Averaging (hereafter DCA) policies. For a given amount of dollars, the former is to invest a mutual fund outlaying all money at one time immediately; the latter only outlays part amount at a time and sequentially pursues the investment every other period (*e.g.*, monthly). The DCA policy is advocated by some scholars and many practitioners, as well as long recommended by investment textbooks (*e.g.*, Smith *et al.*, 1992, pp. 613-614) and personal finance books (*e.g.*, Goodman and Bloch, 1994). DCA is generally perceived as having a function of forced savings and avoiding the consumption of earnings (Leggio and Lien, 2001, 2003). Additionally, DCA approach is a time-honored way of trying to increase long-term investment returns and decrease average costs due to investing through time (Edleson, 1988; Milevsky and Posner, 2003), as well as reduce risks which occur by selecting an improper time to invest (Dubil, 2005; Malkiel, 1999). It may even help investors avert regrets resulting from investing errors (Statman, 1995).

However, very little theoretical literature and empirical evidence exists to support the DCA strategy. The theoretical research tends to focus on the subjects of rational decision making under uncertainty for optimality of DCA, based on the viewpoint of utility maximizing and risk aversion (*e.g.*, Constantinides, 1979; Knight and Mandell, 1993; Pye, 1971). The empirical literature employs historical or simulating data to investigate the tradeoff between return and risk from both DCA and LS approaches (Abeysekera and Rosenbloom, 2000; Atra and Mann, 2001; Bacon *et al.*, 1997; Leggio and Lien, 2003; Rozeff, 1994; Williams and Bacon, 1993). The results from both researches are generally unfavorable to DCA.

Under a given investment horizon for mutual funds and all else being equal, can the LS or DCA policy create higher risk-adjusted returns? And what is the potential reason? This question is what the present paper wishes to research empirically, due to both the mixed results of previous studies and DCA's widespread popularity among the investing public.

Generally, if a fund's net asset value per share (NAV) goes up incessantly over an investment horizon, LS approach will yield higher returns than DCA. If the NAV trend is down continually, DCA will have more favorable returns than LS (Bierman, Jr. and Hass, 2004). Since one can not predict precisely the future path of a fund's price, whether or not a DCA strategy beats a LS strategy is an important issue for investors. Previous studies have shown that DCA's return relative to LS depends critically on the sequence of prices (*e.g.*, Abeysekera and Rosenbloom, 2000). Numerous articles specify sample periods begin from either 1926 or 1970 in the U.S. and either 1971 or 1981 in Taiwan (see Table 1 in Section 2), having low index relative to the sequence of index later. This paper thus conjectures the specification of the beginning time of sample period likely influences the comparison result of the performance of investment policies. Additionally, Israelsen (1999) suggested that DCA seems to work better with low standard deviation funds, while equity funds with a high standard deviation of return appear to be generally well appropriate for LS investing. Nevertheless, Abeysekera and Rosenbloom (2000) argued that one benefit the DCA has over LS is in reducing risk and hence may be an suitable policy for volatile stocks; the cause is that higher volatility offers a higher probability to reduce average costs. This paper also seeks to investigate the effects of the sequence of price and return volatility on the performance of investing strategies.

This study uses open-end equity mutual funds that are traded in Taiwan as a sample. The LS and DCA approaches are employed to perform simulating investment for a few different horizons. Using *t*- and nonparametric tests, both the simple and compounded returns between two approaches are compared, respectively. To ensure that the comparison between DCA and LS is based on an identical basis, the following procedures are conducted:

(1) Both original and risk-adjusted returns are considered. This is done because the risk of a LS strategy may be higher than DCA's (Atra and Mann, 2001; Rozeff, 1994).

(2) The risk-free investing income (*e.g.*, deposit returns) of the rest of the capital which has not yet been invested into the funds selected by DCA strategy within the investment horizon is incorporated to make the entire amount of dollars invested equivalent. This is a way of considering the opportunity cost of not investing immediately.[1] In addition, this paper alternatively assumes that the risk-free return equals zero so as to compare its result with that of previous studies and to investigate the effect of risk-free return on DCA's performance. The conscientious courses would make the study relatively correct.

The distinguishing features of this study include:

(1) Using real NAV data on 229 mutual funds, instead of stock market indexes and/or security portfolios (employed by Atra and Mann, 2001; Rozeff, 1994; Williams and Bacon, 1993, and

[1] Bacon *et al*. (1997), Leggio and Lien (2001), and Williams and Bacon (1993) have adopted a similar method where the DCA approach contains two projects, stock market index and Treasury bills investments.

others), which seems to be just equivalent to a single funds. The strength is that the simulated investment draws near a real situation for mutual funds investment and thus this paper's result should be substantially representative.

(2) Considering seven different investment horizons (quarterly, semi-annual, annual, and two through five years) rather than only one year, based on the claims from Dubil (2005) and Olsen and Khaki (1998) that DCA can reduce risk with investment life extending. Numerous previous studies used periods of no more than 12 months, and therefore their results may not be robust for long-term investments (*e.g.*, Abeysekera and Rosenbloom, 2000; Atra and Mann, 2001; Bacon *et al.*, 1997; Leggio and Lien, 2001, 2003; Rozeff, 1994; Williams and Bacon, 1993). Moreover, we suppose the investment programs of each month are independent rather than investing after the last program has been liquidated (the procedure has been used by Rozeff (1994)). This study recognizes Rozeff's procedure may invoke a selective bias of investment time point; avoiding the bias in this paper could obtain relatively correct results.

(3) Not only simple returns are considered but also compounded returns are examined to assure validity of the conclusion from this paper. This paper derives formulas for both simple and compounded returns from the DCA and LS strategies, respectively; as such, the rate of returns can be computed easily.

(4) Using Taiwan stock index as a sample with various start times for simulating investment to perform the robustness check to examine the effects of the sequence of price and return volatility (measured by variance coefficient), while the domestic literature does not observe the effect of the volatility.

The main finding is that DCA is a more efficient approach than LS investing in the long run. Implementing a DCA approach, risk is reduced and return is enhanced with the extension of the investment horizon. This is contradictory to numerous previous studies designing merely some short-term horizons and not considering variations of returns (*e.g.*, several domestic studies, see Table 1 in Section 2). The difference in performance of between DCA and LS may be influenced by the price sequence and volatility. The DCA could work best with highly volatile security. Thus, this paper suggests that investors should adhere to practitioners' recommendation to adopt DCA for mutual fund investment with a long-term strategy, better for one year or longer.

2. Literature Review

Which approach can offer higher performance (or terminal wealth) under equal amounts of investment, LS or DCA? Previous literature has found mixed results on this issue. Both Constantinides (1979) and Pye (1971) showed theoretically that DCA is not appropriate for investing based on maximizing personal expected utility. Knight and Mandell (1993) illustrated the suboptimality of DCA by calculating the loss in expected utility in the first few periods where the investor is less than fully invested in the stock market. Bierman, Jr. and Hass (2004) recognized that DCA does not reduce risk or increase expected return in a normal situation; if cash funds are currently available, LS is the optimum investment option, leaving out behavioral considerations and assuming there is an opportunity cost of not investing immediately.

Several studies compare performance between the DCA and LS policies from a historical data-based perspective. Williams and Bacon (1993) compared the annualized returns from three DCA strategies (3-, 6-, and 12-month horizons) with those generated by LS investing from 1926 to 1991. Using simulation procedures, they invested in the S&P 500 Stock Index using the LS strategy and, besides, added U.S. 90-day Treasury bills (a proxy of risk-free assets for DCA investing) by DCA. Their results suggested that the LS significantly outperformed the DCA approach and therefore investors wishing to make cash investments in the market should act as soon as possible. Rozeff (1994) employed simulated investment into actual U.S. stocks (S&P 500 Index and small firms), from 1926 to 1990; the author adjusted the amounts invested in LS on an ex post basis so as to generate identical standard deviations as the DA policy, then the terminal values between two policies are compared. The conclusion is that DCA is inferior to LS strategy, particularly in small-firm portfolios, because of DCA's mean-variance inefficient. Bacon *et al.* (1997) used historical returns on U.S. bonds between 1926 and 1995 to demonstrate that an investor would have been better off with a LS strategy as opposed to DCA. Abeysekera and Rosenbloom (2000) created simulated prices for assets to test the effectiveness of DCA; results indicated no clear advantage for DCA over a LS policy and suspect the validity of the claim that DCA delivers superior returns for high volatility stocks, but the chances of LS outperforming DCA decrease as volatility increases; LS outperforms DCA but exposes the investor to greater risk. Atra and Mann (2001) used several international equity indices as investing instruments for the 1970 - 1998 period and depended on self-financing concepts to compare performance of LS with that of DCA approach. Their results suggest DCA is neither as effective as the personal finance literature argues nor as sub-optimal as the academic literature argues. Namely, DCA's risk increases rather than decreases while its return is enhanced, and DCA offers both higher return and risk than LS strategy does; the desirability of DCA is profoundly affected by the seasonality of stock returns.[2] Leggio and Lien (2001) used large company stocks (S&P 500 composite) and Ibbotson small company stocks in the U.S. as a sample and computed their monthly returns for 1970 - 1999. They applied prospect theory to generate a value function that requires no investors to be strictly risk averse and empirically compared both Sharpe Index and value function among four investment strategies (LS, buy and hold, DCA, and value average) for both large and small stocks. They found loss aversion explains no the existence of the DCA policy, particularly for relatively volatile assets such as small cap stocks.[3] Moreover, Leggio and Lien (2003) found DCA remains an inferior investing strategy to LS investing using three risk-adjusted performance measures, Sharpe Index, reward-to-semi-variance, and upside potential ratios.[4] Several studies using Taiwan stock index as an investment vehicle also claimed that they found the LS outperforms DCA policy; *e.g.*, Huang (1998), Huang (2002), Lin (1997), Lo (2001), and Zhang (2001) (see Table 1).

Conversely, numerous studies pointed out that more shares (units) are purchased with fixed investment amounts as market declines via a DCA strategy, so that both cost per share and risk are reduced, as well as returns are enhanced over a long term (Edleson, 1988; Milevsky and Posner, 2003). Olsen and Khaki (1998) emphasized the validity of the concept of time diversification and argued that risk decreases as investment horizon increases. They indicated that time diversification coincides with current conception of risk and rationality.[5] Domestic researches such as Huang (1998), Huang (2002), and Lin (1997) also found that time diversification effect holds. Malkiel (1999) claimed that DCA can reduce (but not avoid) risk of investing in stocks and bonds by ensuring that the entire stock portfolio will not be purchased at temporarily inflated prices. Israelsen (1999) compared 10-year (1988 - 1998) average annual returns and 10-year holding period returns between DCA and LS strategies for equity funds. The study concludes that DCA is a superior strategy for funds with low

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[2] In really, Atra-Mann result reveals that for February-September period, DCA beats LS investing across international equity indices, regardless of on the basis of returns or Sharpe ratio.

[3] However, for their extended periods DCA's Sharpe Index is larger for small stocks and slightly less for large stocks than LS's for 1950 - 1999. Thus this paper believes that different start times of investment might influence the determination whether LS outperforms DCA.

[4] Dubil (2005) mentioned that Leggio-Lien risk measures depend on variance and semi-variance of returns, not of terminal wealth, and thus their results are driven by the reduced return and not by the risk reduction in DCA.

[5] The current conception of risk, referred to perceived risk by Olsen and Khaki (1998), is that risk should contain "emergent" phenomena and be related to the loss of what one values (Lopes, 1995; Yates, 1992).

Table 1 Lists of Related Empirical Literature

Article	Sample	Period	Method	Result
Panel A: Foreign articles				
Williams and Bacon (1993)	S&P 500 stock index	01/1926-12/1991	Use simulation procedures to compare the annualized returns between LS and DCA for 3-, 6-, and 12-month horizons.	The LS outperforms DCA.
Rozeff (1994)	S&P 500 index and small firm portfolio	01/1926-12/1990	Employ simulation investment and observe the terminal values between two policies, considering variances' impact.	The DCA is inferior to LS strategy, particularly in small-firm portfolios.
Bacon *et al.* (1997)	U.S. corporate and Treasury bonds	01/1926-12/1995	Compare historical annual returns and Sharpe Index between LS and DCA for 3-, 6-, and 12-month horizons.	The LS has both larger original and risk-adjusted returns, though higher risks than DCA. Both returns and risks from DCA decrease as investment horizons extend.
Israelsen (1999)	Equity mutual funds from the Morningstar Principia Pro database	10/1988-09/1998	Compare both average annual returns and 10-year holding period returns and their standard deviations between DCA and LS.	DCA is a superior strategy for funds with low volatility while LS is best for volatile funds.
Abeysekera and Rosenbloom (2000)	Simulated asset prices following a lognormal distribution		Monte Carlo simulation model is developed, and test the effectiveness of DCA by comparing one-year terminal values under various combinations of annual expected returns and risks of stocks.	There is no clear advantage for DCA over a LS policy. One advantage the DCA has over LS is in decreasing risk and thus may be a reasonable policy for volatile stocks.
Atra and Mann (2001)	Several international equity indices (monthly)	01/1970-12/1998	Use paired *t* test to compare annual returns between DCA and LS. The Sharpe Index is also compared.	The DCA is neither effective nor sub-optimal. DCA's risk increases with its return enhancing, and it offers both higher return and risk than LS strategy does (Yet, at least for Feb.-Sep. period, DCA's returns and Sharpe Indexes exceed LS's).
Leggio and Lien (2001)	Large company stocks (S&P 500 composite) and small company stocks in the U.S.	01/1970-12/1999	Use paired *t* test to compare annual value function of the prospect theory among four strategies (LS, buy and hold, DCA, and value average). The Sharpe Index is also compared.	The loss aversion explains no the existence of the DCA policy, particularly for relatively volatile assets. (Yet, for the extended periods, DCA's Sharpe is larger for small stocks and slightly less for large stocks than LS's for 1950-1999).

Article	Sample	Period	Method	Result
Dubil (2005)	Simulated asset prices following a lognormal distribution	—	Use Monte Carlo simulation and compare annual returns for 5- and 15-year periods, standard deviations of terminal values, and shortfall probability.	DCA produce lower volatilities of terminal wealth; the longer the averaging time relative to the total investment horizon, the greater the risk declines. DCA generates a lower expected shortfall when losses occur. The potential cost savings of DCA are dubious.
Panel B: Domestic articles				
Lin (1997)	Monthly stock indexes in Taiwan, U.S., and Japan market	01/1971-02/1997 for Taiwan's data	Use paired *t* test to compare different investment strategies' terminal values for 1-, 2-, 3-, 5-, 10-, 15-, 20-, and 25-year horizons.	Time diversification effect holds. The LS offers larger terminal values than DCA; LS has larger variances.
Huang (1998)	Monthly stock indexes and industry indexes in Taiwan market	01/1981-02/1999	Utilize paired *t* test to compare different investment strategies' terminal values for 1-, 5-, 10-, and 15-year horizons.	Time diversification effect holds. The LS obtains larger terminal values than DCA; LS has larger variances.
Zhang (2001)	Monthly stock indexes in Taiwan and U.S. market	01/1971-02/2001 for Taiwan's data	Use paired *t* test to compare different investment strategies' terminal values for 1-, 2-, 3-, 4-, 5-, 10-, 15-, 20-, and 25-year horizons.	The LS dominates DCA; LS has larger variances.
Lo (2001)	Monthly stock indexes in Taiwan	01/1971-12/2000	Employ paired *t* test to compare different investment strategies' rates of return for 2-, 4-, 6-, 8-, 10-, and 12-month horizons.	The LS outperforms DCA policy; LS has larger standard deviations.
Huang (2002)	Monthly stock indexes in 8 countries, including Taiwan	01/1971-01/2002 for Taiwan's data	Use paired *t* test to compare different investment strategies' terminal values for 0.5-, 1-, 2-, 3-, 4-, 5-, 10-, and 15-year horizons.	Time diversification effect holds. The LS dominates DCA policy.
Li (2004)	50 open-end equity mutual funds	01/2000-12/2004	Utilize one-way ANOVA to examine funds' terminal values and risks.	For five-year horizon and down market, DCA has larger terminal values, whereas LS has larger variances.

volatility while LS is best for volatile funds; contrary to popular opinion, LS investing doesn't always cause superior returns over DCA. However, Israelsen's (1999) result may not be robust because he controls no the sequence of price, which has been shown to have influence on the performance of LS and DCA policies by previous numerous studies; his result possibly only confirms that DCA offers higher returns than LS investing. Using simulation, Dubil (2005) argued that DCA can produce a lower volatility of the terminal wealth of the investment—that is, a more definite outcome; the longer the averaging time relative to the total investment horizon, the greater the risk declines. Moreover, DCA results in a much lower expected shortfall when losses occur. The cost benefit of (DCA) is dubious, since one cannot predict the path of prices. Therefore, Dubil concludes that risk reduction (and not cost savings) should be used as a main suggestion as recommending DCA-like automatic investment plans to long-term investors. As to domestic study, Li (2004) found that DCA has higher holding period returns and lower variances than LS for five-year horizon from 2000 to 2004 and for the down stock market; for the up and trend-blurred market, LS's return is larger than DCA's but risk is higher. The empirical articles related to comparison of performance between LS and DCA strategies are displayed in Table 1.

Behavioral viewpoint is also applied to explain DCA's advantage. Pye (1971) derived that DCA is a better policy from a belief of minimax regrets because investors cannot predict the sequence of prices and therefore a DCA strategy can mitigate mental anguish resulting from improper investing decisions. Statman (1995) presented a behavioral framework for DCA approach based on Kahneman-Tversky prospect theory and the concept of aversion to regret; he asserts it is normal behavior to allot an amount of dollars into segments and invest one segment at a time according to a prearranged plan, thus avoiding market-timing decisions. Bacon *et al.* (1997) mentioned that investors' emotions play a major role in investment decisions; investing without undue fear is often more important than maximizing investment performance. Since DCA reduces risk, it also may help to reduce investor fear. Milevsky and Posner (2003) demonstrated that the expected return from a DCA approach will uniformly surpass the return from the underlying security; this conclusion is dependent on: 1) the investor knowing the final value of the security, and 2) enough volatility in the underlying security. Though Milevsky and Posner tend to conclude that DCA is irrational and mean variance inefficient, they offer their research as a complement to Statman's behavioral theory. Dubil (2005) recommended that retirement investors should take advantage of automatic savings plans over very long periods in order to minimize disappointment when investment results are poor.

As to the foreign literature, above-mentioned empirical studies designed investment life not longer than one year. Both Bacon *et al.* (1997) and Williams and Bacon (1993) used only three short (3-, 6-, and 12-month) horizons; Rozeff's (1994) longest investment horizon was just twelve months. Also, Abeysekera and Rosenbloom (2000), Atra and Mann (2001), and Leggio and Lien (2001, 2003) examined merely twelve months as an investment life. Their results may fail to be applied to long-term investments. Also, short horizons may fail to sufficiently reduce average costs and diversify risks, which would be DCA's advantage. Further, as the investment time points Rozeff (1994) designs do not include each month, they might result in a selective bias for investment timing. Instead, Israelsen (1999) observed 10-year investment performance, and Dubil (2005) presented 5- and 15-year risk profile of DCA versus LS investing. They obtained different results relative to that of the above studies; therefore, considering investment horizons longer than twelve months should be critical.

With respect to the domestic literature, most of the cited articles compare only terminal wealth or rate of return but ignore the magnitude of variance or standard deviation between DCA and LS, except for Li (2004), such possibly draws incorrect conclusion. Although they argued that directly observing terminal values conforms to investors' intuition, high volatilities/variances there may be no way to provide regular gains. In fact, their results indicate that the LS investing is exposed to higher risks. Moreover, their sample periods begin in either 1971 or 1981, a time Taiwan stock market has not yet risen and flourished, this is likely favorable for the LS investing, as with the argument that whether LS beats DCA or not relies heavily on the sequence of prices (Abeysekera and Rosenbloom, 2000). Israelsen (1999) and Li (2004) used 1998 and 2000, respectively, as the start points of sample periods -- dissimilar from alternative studies that concluded LS beats DCA -- and found that DCA outperforms LS policy. In sum, it is necessary to concurrently consider both the return and risk (variance/standard deviation) as comparing the performance between different investing strategies. Also, the specification of the beginning point of simulating investment's horizon is also important for the performance of investing policies, such that we can control the impact of the sequence of price.

3. Data

This study collects all open-end equity mutual funds, traded by NAV, as a sample from the Taiwan Economic Journal (TEJ) Data Bank between January 2000 and May 2006, a total of 77 months. The number of funds is 229 and their NAVs on the first trading day of each month as well as both the date and amount of distributing dividends are adopted. Not all sample funds have 77 NAVs because part of them: 1) changed attribute from close-end to open-end during the sample period; 2) had exited from the funds market, and 3) began trading after Jan. 2000. Namely, the first day for NAV data is not Jan. 2000 for part of funds and, therefore, the number of NAVs is 13,299 rather than 17,633. But this affects no the test jobs in this research. This point will be discussed in detail in a later paragraph.

Previous studies have shown that DCA's return relative to LS's depends crucially on the sequence of prices. Thus, this paper pre-examines the average trend of sample funds' NAVs and plots them in Figure 1. To diminish the size effect of the funds, the mean of $NAV_{i,t}$ across funds at the same month is formulated as: Mean ($NAV_{i,t}$) = $(1 / N)\Sigma_i [NAV_{i,t} - \Sigma_t (NAV_{i,t}) / T]$, where i denotes funds, N is the number of the sample funds, t is time (month), and T represents the number of months. Figure 1 reveals that the trend of sample funds over the sample period is considerably volatile and does not develop at a fixed fashion. By calculation, the average monthly return is -0.34 with a standard deviation of 4.78 over the sample period. In fact, the high volatility should be a typical condition for most assets' prices in the long term.

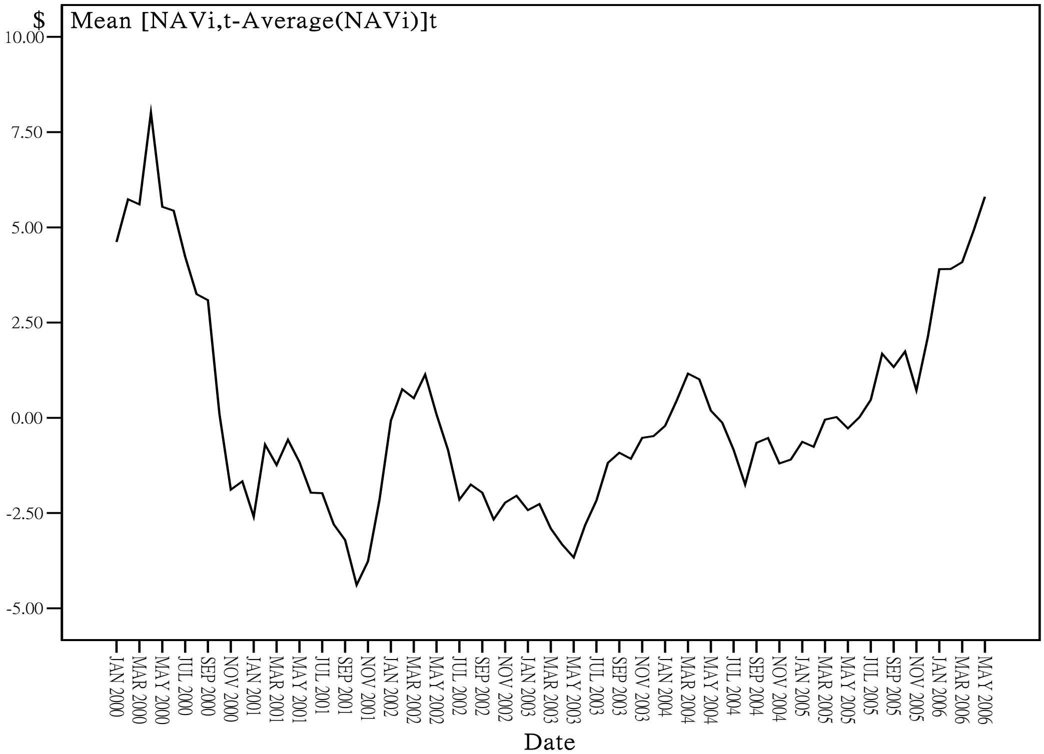

Figure 1 The average trend of sample funds' NAVs

4. Methodology

To take account of the effect of horizons' length and/or investing point of time as well as the type of returns (*i.e.*, simple or compounded) on performance of investing strategies for mutual funds, this article makes mature designs for these factors. First, investment horizons include 7 types, which are one quarter, semi-annuity, and one through five years, in order to ensure that the comparison results are robust for various investment horizons.

Second, to mitigate the impact of different time point of investing on returns, the specification is as follows.[6] Here take one-year horizon as an example and suppose that the sample period is 01/2000 - 05/2006: the first (second) investment horizon is from the first trading day on 01/2000 (02/2000) to the first day on 01/2001 (02/2001). That is, the first trading day of each month is the first outlay day of an investment, then this day is moved onwards every month until 05/2005 and the length of the horizon is kept to be one year. Note that each investment program is mutually independent. A return is computed in an investment and is an observation for the equality test job. 65 observations are obtained when the sample period is 01/2000 - 05/2006. Stacking up all sample funds' returns of all horizons, where the returns are calculated by LS and DCA investments, respectively, two series are generated and the paired-sample comparison tests can be carried out. This method possesses at least two merits: 1) the number of observations is expanded, and 2) since the investment is performed each month for each fund and the pair comparison returns are on the same funds as well as their identical outlay days and investment horizons, the result of the performance comparison will not be influenced by investing timing and by a particular fund. Namely, the result will be on an average and overall view. Note that the return comparison requires no a sample period of any fund to be identical because it is the returns of a fund on the same horizon are paired to conduct a difference comparison, where the returns are separately yielded by two investing strategies.

Finally, this paper calculates two types of returns, simple and compounded, to guarantee thorough examination. Holding-period rate of return is transformed to annualized form in order to make the returns comparable across various horizons and with the opportunity cost of capital. Moreover, the funds' dividends during the holding period, if any, are automatically reinvested to buy additional shares

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[6] A similar design have ever been adopted by Bacon *et al.* (1997) and Williams and Bacon (1993), but they did not mention the function of mitigating the influence of investment point of time and used only three-, six-, and twelve-month horizons.

based on NAV of the distributing days.　Taxes and transaction costs are ignored to purify the effect of investment strategies.

The formula of the annualized rate of return is as follows. Let the number of periods (months) of investment equals P.　Assume that the total amount of money equals \$1 and zero borrowing.

4.1 LS Strategy

Since the total dollar amount of investment is \$1, the initial outlay at the start of investment period is also \$1. The annualized rate is:

(1) Simple return:

$$\left[U(1+\frac{D}{NAV_D})\times NAV_1 - 1\right]\times\frac{12}{P} \tag{1}$$

(2) Compounded return:

$$\left[U(1+\frac{D}{NAV_D})\times NAV_1\right]^{\frac{12}{P}} - 1 \tag{2}$$

where U denotes the number of shares bought at the start of period, D is the dividend per share, NAV_D is the NAV at the providing day of dividend, and NAV_1 denotes the NAV at the end of the Pth period.

4.2 DCA Strategy

This paper here considers investing return on residual funds which wait to be invested into the pre-selected mutual funds during a given horizon in order to guarantee that DCA and LS policies are starting with equal wealth.　Assume that the accompanying investment is a deposit in a bank, belonging to a kind of risk-free asset, so a DCA strategy can be viewed as two investment projects: one is bank deposit, the other is mutual funds, where the entire amount is initially invested in deposits and then gradually shifted to mutual funds in equal monthly installments. Let r denotes the interest rate on deposit. \$1/P is outlaid at the beginning of each month (*i.e.*, dividing the initial sum, \$1, into segments for future investments).

The annualized return for the funds is:

(1) Simple return (*SFR*):

$$(\mathrm{FV}-1)\times 12/\mathrm{P} \tag{3}$$

where FV is the total terminal value of funds at the end of P periods (= NAV at the end of period × the cumulative shares purchased). The cumulative shares include the shares bought by dividends reinvested to the same funds over investment period. Let the shares that have been held prior to immediately providing dividends equals CU. Then the total shares after distributing dividends equal $CU(1 + D / NAV_D)$.

(2) Compounded return (CFR):

$$(1+FRM)12-1 \tag{4}$$

where FR_M represents monthly rate of return of funds, computed by the following equation:

$$1/P \times FVIFA(P,FRM) \times (1+FRM) = FV \tag{5}$$

where $FVIFA(P,FR_M)$ is the future value of an annuity interest factor for P months with monthly rate FR_M.

The annualized return for the deposit is as follows (see Appendix):

(1) Simple return (SDR)

$$SDR = \frac{r(P-1)}{P} \tag{6}$$

(2) Compound return (CDR)

$$CDR = \left[(1+\frac{r}{12})^P - \frac{r}{12}\right]^{12/P} - 1 \tag{7}$$

Then the annualized simple return of DCA approach equals ($SFR + SDR$) and the compounded return is ($CFR+CDR$). Further, this study lets r equals and is larger than zero, respectively, to see the effect of r on the return comparison results.

In addition to comparing original annualized returns, the risk-adjusted returns between two investment strategies are also compared, where the risk-adjusted returns equal the original returns over the standard deviation of return series for either LS or DCA.[7] This procedure allows the returns to be compared under equivalent risks because the risks taken between LS and DCA are obviously distinct (Atra and Mann, 2001; Rozeff, 1994). The standard deviation of the return series reveals the volatility of the terminal value of the investment and thus represents the degree of risk (Dubil, 2005).

With respect to statistical method of equality tests, both the paired-sample t-test for mean equality

[7] In fact, this approach is qualitatively identical to Rozeff (1944) that adjusts LS's outlay to equate the variances between DCA and LS. The proof is available upon request.

and the Wilcoxon Signed Ranks test for median equality, a nonparametric approach, are performed in this research. The returns of a fund from DCA versus LS over the same period of time are paired and entire sample funds are used.

5. Results

5.1 Descriptive Statistics

Descriptive statistics of original returns on funds are shown in Table 2 and those of risk-adjusted returns in Table 3, where the returns are calculated by the above-mentioned formulas. The returns by DCA policy contain the returns on deposit with the annual rate of interest 1%.[8] Tables 2 & 3 show that DCA policy creates larger returns (both mean and median) than LS investing except in the cases of simple original returns' means for 3- and 6-month horizons as well as the same returns' median for 12-month investment.

To compare the risk degree that two strategies face, the variance coefficient, standard deviation divided by mean, is calculated to measure risk loading under equivalent returns in Table 2. The result indicates that DCA's risk is relatively lower than LS's; in particular, as the horizons extend, the risk differences substantially increase. This is consistent with the suggestions from Atra and Mann (2001) and Rozeff (1994) that the risk of DCA is lower than LS's, along with the arguments that risk reduces as investment horizon increases by Dubil (2005), Huang (1998), Huang (2002), Lin (1997), Milevsky and Posner (2003), and Olsen and Khaki (1998).

Examining the Std. Dev. of returns in Table 2, the return volatility declines with horizons extending regardless of DCA or LS policies. This seems to offer evidence that mutual funds should be long-term investment instruments. An investment to mutual funds should be made in the long run. Further, for risk-adjusted compounded returns in Table 3, the maximal and minimal averages equal 22.17% (122.40%) and -4.14% (23.22%), respectively, under LS (DCA) strategy; the former occurs as the horizon is 3 (60) months, the latter occurs as the horizon is 60 (6) months. Actually, no matter which Table is considered, the returns resulting from DCA vary parallel with investment horizons when the horizon is longer than about 12 months, while LS's returns have no this phenomenon. Additionally, the differences in returns between DCA and LS increase with prolonged horizons, revealing that DCA is more appropriate for long-term investments than LS policy.

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8 When the rates of interest for deposits are 0% and 2%, the results are qualitatively the same. As the interest rate equals 3%, DCA always beats LS. See later analysis.

Table 2　Descriptive Statistics of Annualized Original Returns on Outlay $1

	Horizon (months)	*N*	Mean	Std. Dev.	Variance coefficient	Min.	Max.	Median
Panel A: Simple return								
LS	3	12612	0.0407	0.7065	17.3587	-1.8683	4.0983	0.0259
DCA	3	12612	0.0327	0.4907	15.0061	-1.5315	2.8394	0.0347
LS	6	11925	0.0312	0.4823	15.4583	-1.1969	2.3323	0.0221
DCA	6	11925	0.0299	0.3145	10.5184	-0.9051	1.4317	0.0258
LS	12	10568	0.0305	0.2941	9.6426	-0.6203	1.1006	0.0359
DCA	12	10568	0.0420	0.1800	4.2857	-0.4829	0.6485	0.0307
LS	24	8075	0.0330	0.1519	4.6030	-0.3458	0.686	0.0348
DCA	24	8075	0.0541	0.0850	1.5712	-0.2109	0.4675	0.0475
LS	36	5887	0.0483	0.1597	3.3064	-0.2679	0.8319	0.0311
DCA	36	5887	0.0562	0.0748	1.3310	-0.1351	0.3843	0.0501
LS	48	3901	0.0266	0.1063	3.9962	-0.1847	0.5291	0.0147
DCA	48	3901	0.0619	0.0565	0.9128	-0.0572	0.3077	0.0521
LS	60	2151	0.0127	0.0964	7.5906	-0.1517	0.3637	-0.0106
DCA	60	2151	0.0683	0.0571	0.8360	-0.0315	0.3909	0.0575
Panel B: Compounded return								
LS	3	12612	0.2576	1.1622	4.5116	-0.9193	15.8006	0.0262
DCA	3	12612	0.3025	1.2615	4.1702	-0.9455	20.7966	0.0495
LS	6	11925	0.0896	0.5239	5.8471	-0.8388	3.6921	0.0222
DCA	6	11925	0.1400	0.6029	4.3064	-0.8882	4.6971	0.0386
LS	12	10568	0.0305	0.2941	9.6426	-0.6203	1.1006	0.0359
DCA	12	10568	0.0869	0.3379	3.8884	-0.7435	1.3647	0.0492
LS	24	8075	0.0215	0.1501	6.9814	-0.4446	0.5402	0.0342
DCA	24	8075	0.0895	0.1570	1.7542	-0.4516	0.7821	0.0816
LS	36	5887	0.0252	0.1481	5.8770	-0.4189	0.5177	0.0302
DCA	36	5887	0.0877	0.1332	1.5188	-0.3267	0.5653	0.0853
LS	48	3901	0.0114	0.0988	8.6667	-0.285	0.3286	0.0144
DCA	48	3901	0.0974	0.0908	0.9322	-0.1390	0.4231	0.0874
LS	60	2151	-0.0037	0.0898	a	-0.2474	0.2303	-0.0108
DCA	60	2151	0.1035	0.0845	0.8164	-0.0806	0.4520	0.0948

Notes: The rates of return by DCA include deposit returns with the interest rate of 1%. *N* is the number of observations. “a” denotes that the mean is negative and thus the variance coefficient is meaningless.

Table 3 Descriptive Statistics of Annualized Risk-Adjusted Returns on Outlay $1

	Horizon (months)	*N*	Mean	Std. Dev.	Min.	Max.	Median
Panel A: Simple return							
LS	3	12612	0.0576	1	-2.6443	5.8005	0.0367
DCA	3	12612	0.0666	1	-3.1209	5.7861	0.0707
LS	6	11925	0.0646	1	-2.4814	4.8353	0.0457
DCA	6	11925	0.0952	1	-2.8779	4.5523	0.0820
LS	12	10568	0.1036	1	-2.1088	3.7416	0.1221
DCA	12	10568	0.2335	1	-2.6824	3.6023	0.1703
LS	24	8075	0.2172	1	-2.2759	4.5155	0.2293
DCA	24	8075	0.6366	1	-2.4822	5.5022	0.5590
LS	36	5887	0.3021	1	-1.6775	5.2092	0.1949
DCA	36	5887	0.7522	1	-1.8070	5.1402	0.6701
LS	48	3901	0.2500	1	-1.7367	4.9755	0.1379
DCA	48	3901	1.0970	1	-1.0129	5.4486	0.9226
LS	60	2151	0.1312	1	-1.5734	3.7726	-0.1097
DCA	60	2151	1.1947	1	-0.5513	6.8412	1.0063
Panel B: Compounded return							
LS	3	12612	0.2217	1	-0.791	13.5949	0.0225
DCA	3	12612	0.2398	1	-0.7495	16.4861	0.0392
LS	6	11925	0.1710	1	-1.6011	7.0476	0.0423
DCA	6	11925	0.2322	1	-1.4731	7.7904	0.0640
LS	12	10568	0.1036	1	-2.1088	3.7416	0.1221
DCA	12	10568	0.2572	1	-2.2007	4.0393	0.1455
LS	24	8075	0.1432	1	-2.9614	3.5978	0.2281
DCA	24	8075	0.5701	1	-2.8768	4.9821	0.5198
LS	36	5887	0.1703	1	-2.8279	3.4951	0.2039
DCA	36	5887	0.6580	1	-2.4526	4.2438	0.6404
LS	48	3901	0.1150	1	-2.8852	3.3268	0.1453
DCA	48	3901	1.0728	1	-1.5311	4.6605	0.9627
LS	60	2151	-0.0414	1	-2.7559	2.5658	-0.1204
DCA	60	2151	1.2240	1	-0.9534	5.3467	1.1214

Notes: The rates of return by DCA approach include deposit returns with the interest rate of 1%. Since the returns are deflated by their original Std. Dev., the Std. Dev. all equal one. *N* is the number of observations.

5.2 Performance Comparison

Tables 4 & 5 report the testing results for return equality between the DCA and LS policies. When the deposit return in DCA approach is dismissed (*i.e.*, the interest rate on deposit equals zero), the results in both Tables 4 and 5 are mixed both for the horizons of no more than six months and for the simple returns. We can not determine whether the DCA is superior to LS because the outcomes of two statistical tests are inconsistent.

Table 4 The Equality Test of Original Annualized Returns between LS and DCA Investing

The interest rate on deposits	0%			1%			3%		
P	Mean dif. ($)	*t*-value	Z-value	Mean dif. ($)	*t*-value	Z-value	Mean dif. ($)	*t*-value	Z-value
Panel A: Simple return									
3	0.0147	5.69 [a]	-2.00 [b]	0.0080	3.11 [a]	-4.90 [a]	-0.0053	-2.06 [a]	-10.61 [a]
6	0.0096	4.07 [a]	-1.87 [c]	0.0012	0.52	-5.77 [a]	-0.0154	-6.56 [a]	-13.45 [a]
12	-0.0084	-1.96 [b]	-5.60 [a]	-0.0116	-7.06 [a]	-10.90 [a]	-0.0299	-18.25 [a]	-21.17 [a]
24	-0.0115	-9.34 [a]	-8.36 [a]	-0.0211	-17.12 [a]	-16.04 [a]	-0.0403	-32.67 [a]	-30.68 [a]
36	-0.0017	-1.33	-3.94 [a]	-0.0080	-6.14 [a]	-11.01 [a]	-0.0274	-21.09 [a]	-24.02 [a]
48	-0.0256	-20.55 [a]	-22.43 [a]	-0.0354	-28.42 [a]	-28.27 [a]	-0.0549	-44.16 [a]	-37.47 [a]
60	-0.0458	-36.14 [a]	-29.30 [a]	-0.0556	-43.91 [a]	-32.43 [a]	-0.0753	-59.43 [a]	-36.51 [a]
Panel B: Compounded return									
3	-0.0382	-9.60 [a]	-4.45 [a]	-0.0449	-11.28 [a]	-7.81 [a]	-0.0584	-14.68 [a]	-14.64 [a]
6	-0.0420	-13.61 [a]	-7.51 [a]	-0.0504	-16.33 [a]	-11.65 [a]	-0.0674	-21.81 [a]	-20.01 [a]
12	-0.0472	-27.41 [a]	-29.42 [a]	-0.0564	-32.76 [a]	-34.26 [a]	-0.0751	-43.62 [a]	-43.42 [a]
24	-0.0584	-43.88 [a]	-35.00 [a]	-0.0680	-51.12 [a]	-41.52 [a]	-0.0876	-65.83 [a]	-53.87 [a]
36	-0.0527	-59.49 [a]	-48.36 [a]	-0.0624	-70.53 [a]	-53.19 [a]	-0.0823	-92.97 [a]	-59.89 [a]
48	-0.0762	-65.56 [a]	-46.60 [a]	-0.0860	-74.03 [a]	-49.12 [a]	-0.1060	-91.24 [a]	-52.18 [a]
60	-0.0973	-92.76 [a]	-40.05 [a]	-0.1072	-102.19 [a]	-40.13 [a]	-0.1273	-121.34 [a]	-40.17 [a]

Notes: The two-tailed *t*- and the Wilcoxon signed ranks tests for paired samples (LS－DCA) are performed. Z-value is the statistic of Wilcoxon test, negative indicating DCA＞LS. The number of observations can be found in Table 2. Superscripts “a”, “b”, and “c” represent significance at the 1%, 5%, and 10% levels, respectively.

Table 5 The Equality Test of Risk-Adjusted Annualized Returns between LS and DCA

The interest rate on deposits:	0%			1%			3%		
P	Mean dif. ($)	*t*-value	Z-value	Mean dif. ($)	*t*-value	Z-value	Mean dif. ($)	*t*-value	Z-value
Panel A: Simple return									
3	0.0046	1.57	5.18 [a]	-0.0090	-3.07 [a]	0.20	-0.0362	-12.35 [a]	-9.78 [a]
6	-0.0041	-0.89	2.07 [a]	-0.0306	-6.69 [a]	-4.73 [a]	-0.0836	-18.29 [a]	-18.32 [a]
12	-0.0790	-15.09 [a]	-19.07 [a]	-0.1299	-24.81 [a]	-28.22 [a]	-0.2317	-44.27 [a]	-44.33 [a]
24	-0.3066	-35.50 [a]	-29.07 [a]	-0.4194	-48.56 [a]	-41.21 [a]	-0.6450	-74.68 [a]	-60.53 [a]
36	-0.3201	-51.20 [a]	-44.34 [a]	-0.4501	-72.00 [a]	-54.11 [a]	-0.7102	-113.60 [a]	-63.32 [a]
48	-0.6736	-54.69 [a]	-42.75 [a]	-0.8470	-68.77 [a]	-47.54 [a]	-1.1937	-96.92 [a]	-52.26 [a]
60	-0.8914	-70.25 [a]	-39.31 [a]	-1.0635	-83.81 [a]	-39.88 [a]	-1.4077	-110.93 [a]	-40.15 [a]
Panel B: Compounded return									
3	-0.0128	-4.01 [a]	-7.09 [a]	-0.0182	-5.66 [a]	-10.40 [a]	-0.0289	-9.01 [a]	-16.91 [a]
6	-0.0473	-8.85 [a]	-9.66 [a]	-0.0612	-11.45 [a]	-13.62 [a]	-0.0894	-16.72 [a]	-21.48 [a]
12	-0.1263	-23.86 [a]	-27.68 [a]	-0.1535	-29.01 [a]	-32.33 [a]	-0.2089	-39.47 [a]	-41.08 [a]
24	-0.3655	-42.26 [a]	-33.92 [a]	-0.4269	-49.35 [a]	-40.38 [a]	-0.5516	-63.76 [a]	-52.57 [a]
36	-0.4144	-67.40 [a]	-51.90 [a]	-0.4877	-79.34 [a]	-56.17 [a]	-0.6368	-103.58 [a]	-61.78 [a]
48	-0.8494	-69.64 [a]	-48.09 [a]	-0.9578	-78.53 [a]	-50.34 [a]	-1.1781	-96.59 [a]	-52.84 [a]
60	-1.1484	-95.92 [a]	-40.09 [a]	-1.2654	-105.69 [a]	-40.14 [a]	-1.5030	-125.54 [a]	-40.17 [a]

Notes: The *t*- and the Wilcoxon signed ranks tests for paired samples (LS－DCA) are performed. Z-value is the statistic of Wilcoxon test, negative indicating DCA＞LS. The number of observations can be found in Table 2. Superscripts “a” represent significance at the 1% level.

When a deposit return of 1% per year is incorporated, the test results for simple returns over a three-month horizon between Tables 4 and 5 are also not identical, but those for six-month horizons tend to come in line gradually. In fact, for risk-adjusted returns (regardless of simple or compounded type), the DCA always performs better than the LS if the horizon is longer than or equal to six months with a deposit return of 1%. When deposit return rises to 3%, DCA significantly (at the 1% level) outperforms LS under two types of returns in Tables 4 & 5 for any horizon, where the advantage of risk-adjusted compounded return in DCA at three and sixty months is 2.89% and 150.30%, respectively. Thus, the deposit return will affect performance of DCA and, therefore, the comparison results between DCA and LS policies.

Despite differences in both the type of fund returns and the level of deposit returns, for horizons twelve months or longer, the DCA is superior to LS, statistically significant at the 1% level by two kinds of test statistics. Moreover, no matter whether returns are adjusted for risk, for compounded return and any horizon this study employs, DCA beats LS policy. The DCA's risk-adjusted compounded returns are, on average, about 1.28% and 115% per year larger at three- and sixty- month horizons, respectively, even if deposit return is not taken into account. Obviously, what matters most is the investment horizon, which influences returns of DCA; the longer the horizon, the larger the returns by DCA strategy. As a result, this finding does not agree with Rozeff's (1994) argument that those who hesitate to invest, lose. This study also tends to opposite to others' suggestions that LS beats DCA, yet consistent with Dubil (2005), Israelsen (1999), and Li (2004).

6. Robustness check

Numerous above-cited articles, including domestic studies, employ stock market index as an investment vehicle and found that LS outperforms DCA; instead, the studies with sample being mutual funds conclude opposing results (*e.g.*, Israelsen, 1999; Li, 2004), consistent with the present paper's results. Hence, we attempt to employ the issuance volume-weighted index in the Taiwan Stock Exchange as a sample to compare with the results of mutual funds and, therefore, the period is also from 01/2000 to 05/2006, identical to our mutual funds' sample period. Also, the sample periods for most of the aforementioned studies in Taiwan begin in 1971 or 1981, probably invoking DCA to be inferior to LS.[9] As with the suggestions from Huang (1998) and Lin (1997) that the cause of LS dominating DCA is the frequently up condition for the stock market; when using stock indexes, we alternatively also set various start points of sample periods to observe their effects on the performance (risk-adjusted returns) of the two policies. The start times contain 01/1971, 01/1990, 01/1991, and 07/1988, respectively, and the end times are always 12/1999, facilitating to observe distinctive sequences of price and return volatility. For the Taiwan stock market, the index is 126.89 on January 1971; January 1990 is the approximate time that the market index came to the history highest point for the first time; January 1991 is the rough time that the index collapsed to the relatively low position. July 1988 is the near time that the first moment the index rose toward the position of 6,000, the average of the indexes over December 1986—December 2006, where Dec. 1986 is the first time the index went beyond 1,000.

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9 The indexes in Taiwan stock market is 126.89, 564.40, and 8,448.84 on 01/1971, 01/1981, and 12/1999, respectively.

The result is reported in Table 6. For simplicity, we only display the results concerning the compound returns. The results about the simple returns are qualitatively the same. The returns on DCA contain no the deposit returns of the remaining capital. The last column of Table 6 is the least interest rate on deposit that will render DCA significantly superior to LS, calculated by the following procedures. First, we exploit the Eq. (8), written below, to compute the *CDR*, the compound returns of the remaining capital for investing by the DCA policy; further, the interest rate on deposit can be obtained (according to the Eq. (7)).

$$\frac{\frac{\mu_{DCA}+CDR}{std_{DCA}}-\frac{\mu_{LS}}{std_{LS}}}{ste}=\text{t-value} \quad (8)$$

where the *t*-value meets the condition that the significant level is less or equal to 10%; μ_i (i = DCA or LS) is the mean of the annualized returns; std_i is the standard deviation of the risk-adjusted index returns for the investment policy *i*; *ste* is the standard error that is used in the paired *t*-value in Table 6. Note that since the *CDR* added to the μ_{DCA} is a constant, given a particular investment horizon, both the std_i and *ste* in the Eq. (8) are the same as those used to calculate the risk-adjusted returns and the *t*-values in Table 6.

The results indicate that over the period 01/2000 - 05/2006 the DCA beats LS investing as long as the investment horizons are equal to or longer than 12 months, similar to the results from our mutual funds' sample and from Li (2004). Thus our results should be greatly robust. Moreover, for 01/1971 - 12/1999, though the LS probably outperforms DCA for most of the investment lives,[10] the last column in Table 6 points out that DCA could beat LS as long as the interest rate on deposit is less than 3.28%, which is really easy to achieve. Even if for the period from 01/1991 (with lower index 4023.72) to 12/1999 (index 8448.84), the LS does not beat DCA except for the 36-months horizon; also, DCA could outperform LS so long as the interest rate is less than 1.83%. Finally, when the periods are 01/1990 - 12/1999 and 07/1988 - 12/1999, respectively, DCA is significantly dominant over LS for both 48- and 60-month horizons. Though for 12-, 24-, and 36-month horizons the two policies there are no significantly diverse performance, DCA can easily surpass LS if the interest rate

[10] This might be correlated with the relatively lower index position and volatility, because roughly for the first half of the period 1971 - 1999 the indexes are smooth and less than 1,000 points, but exhibit an extremely up and volatile trend thereafter.

Table 6　The Equality Test of Risk-Adjusted Annualized Index Returns between LS and DCA

Horizon	Mean $_{LS}$ ($)	Mean $_{DCA}$ ($)	*t*-value	*Z*-value	*N*	*r* (%)
Panel A: 01/2000—05/2006						
3	0.1805	0.1453	0.86	1.63	75	7.85
6	0.0879	0.0894	-0.02	0.87	72	4.14
12	-0.0164	0.1321	-1.96[c]	-1.51	66	0.00
24	0.0650	0.7233	-5.45[a]	-3.09[a]	54	0.00
36	0.1532	0.9498	-7.82[a]	-4.26[a]	42	0.00
48	0.0805	3.8279	-15.81[a]	-4.76[a]	30	0.00
60	-0.3186	3.2864	-24.70[a]	-3.72[a]	18	0.00
Panel B: 01/1971—12/1999						
3	0.2128	0.2629	-2.71[a]	-1.49	346	0.00
6	0.3873	0.3650	1.10	1.81[c]	343	3.28
12	0.4727	0.4446	1.13	1.89[c]	337	2.26
24	0.5236	0.5127	0.47	-0.30	325	1.15
36	0.6031	0.5560	1.93[b]	1.17	313	1.60
48	0.7301	0.6361	3.44[a]	3.27[a]	301	2.12
60	0.8853	0.7378	4.78[a]	4.03[a]	289	2.55
Panel C: 01/1990—12/1999						
3	0.2692	0.2245	0.98	1.63	118	12.14
6	0.2260	0.1904	0.70	1.03	115	4.92
12	0.2097	0.3047	-1.43	-0.79	109	0.30
24	0.2972	0.3767	-0.96	-0.80	97	0.65
36	0.6383	0.7302	-0.84	-0.67	85	0.59
48	0.7635	1.3846	-5.92[a]	-5.28[a]	73	0.00
60	0.8341	1.3027	-3.53[a]	-3.12[a]	61	0.00
Panel D: 01/1991—12/1999						
3	0.3203	0.2791	1.11	1.29	106	9.38
6	0.3197	0.2566	1.24	1.11	103	5.18
12	0.3176	0.3135	0.09	0.25	97	1.52
24	0.5237	0.4918	0.40	0.50	85	1.83
36	2.1649	1.0342	7.93[a]	5.92[a]	73	7.70
48	1.1663	1.2631	-1.35	-1.35	61	0.10
60	1.4045	1.3730	0.30	0.13	49	0.78
Panel E: 07/1988—12/1999						
3	0.3140	0.2823	0.73	1.68[c]	136	11.02
6	0.2907	0.2416	0.99	1.41	133	5.57
12	0.2082	0.2040	0.08	0.74	127	2.13
24	0.0514	0.0791	-0.40	-0.25	115	1.16
36	0.2029	0.3244	-1.59	-1.42	103	0.05
48	0.2366	0.5043	-3.90[a]	-3.37[a]	91	0.00
60	0.3755	0.9343	-5.10[a]	-4.34[a]	79	0.00

Notes: The return means are compound ones with zero return on residual capital for DCA policy. The Z-value is the statistic of the Wilcoxon signed ranks test, negative indicating DCA＞LS. *N* is the number of observations. *r* is the least interest rate on deposit that renders DCA significantly outperforming LS. Superscripts “a”, “b”, and “c” represent significance at the 1%, 5%, and 10% level, respectively.

is less than 2.13%. In brief, DCA may dominate LS when the investment horizon is equal to or longer than 12 months, in particular as the remaining capital's returns are considered. This is contrary to the results from the domestic studies except Li (2004), where the potential reason is that their investment periods typically start from the early time of stock market development in Taiwan. According to the results from different start points of simulating periods, we could conclude that the different price sequences have effects on the performance of the investing policies. The higher prices in the beginning of horizon are less beneficial to the LS investing.

Other, there are several useful information obtained from the robustness analysis but not reported in Table 6. The variance coefficients of index returns, representing return (or index) volatility, for the periods in Panels A-E are -51.27, 6.07, 21.66, 9.46, and 10.76, respectively.[11] When the volatility is low, *e.g.*, 1971 - 1999 and 1991 - 1999, DCA approximately is not superior to LS. Instead, when the volatility increases, DCA significantly outperforms LS, particularly for longer investment lives, in line with the results in Tables 4 & 5, where the mutual funds' variance coefficient equals -13.94 over the period 2000 - 2006. In deed, the standard deviations of returns from DCA in Table 6 (not reported) are relatively less than those from LS investing and the standard deviations down with the investment lives extending, consistent with the results in Tables 2 & 3. Therefore, the DCA is able to decrease risk and may be an appropriate strategy for volatile assets. The paper supports the suggestions from Abeysekera and Rosenbloom (2000), Dubil (2005), and Milevsky and Posner (2003) but does not agree with the arguments by Bierman, Jr. and Hass (2004) and Israelsen (1999).

7. Conclusions

The paper empirically compares the difference in short- and long-term returns between DCA and LS strategies in mutual fund investment. Using actual funds' NAVs, this paper formulates the calculation of the annualized returns from LS and DCA investing, containing simple and compounded returns and considering risk-free returns in DCA. The major finding is that DCA possesses higher mean-variance efficiency than LS investing in the long run. In other words, the longer the averaging time relative to the total horizon, the greater the risk reduces and the terminal wealth increases when DCA is adopted. Thus, the DCA is more suitable to long-term investments than LS approach; this is

[11] Over the period 2000 - 2006 the variance coefficient is -51.27, theoretically meaningless due to negative. But we can see the volatility more or less relative to other periods'.

inconsistent with numerous previous studies in which the results are possibly only applied to short-term investments. We believe the reason behind this is that in the longer horizon a high volatility of prices is more likely to be realized if the sample period does not consist of the early era of stock market development (*e.g.*, prior to 1988 for Taiwan market), while DCA's high performance relies on enough volatility in the underlying security. Namely, the sequence of price may generate effect on the performance of investing strategies; the higher prices in the beginning of horizon are less favorable to LS. Moreover, the lower risk-free return is likely to impact performance of DCA in the short term so that the LS might slightly outperform the DCA policy; but when that return boosts, the DCA will beat LS even in the short term. Consequently, investors should accept practitioners' suggestions to adopt DCA for mutual fund investment, ideally employing a long-term strategy, for example, of one year or longer. If one ascertains that the security price is more likely in the low position, the LS policy is better to be implemented, otherwise adopting the DCA strategy. Adopting a DCA investment strategy may not only avoid a form of systematically poor decision-making as the investor has irrational behaviors, but also reduce risk without sacrificing return; this is very important since the sequence of price is not easy to be forecasted, even if the saving of cost is negligible, a dubious benefit as Dubil (2005) mentioned.

Appendix: The Annualized Return of Bank Deposits

The derivation of annualized return for bank deposits is as follows:

(1) Simple return (*SDR*)

$$SDR = \left(\frac{\frac{P-1}{P} \times \frac{r}{12}}{\frac{P-1}{P}} + \frac{\frac{P-2}{P} \times \frac{r}{12}}{\frac{P-2}{P}} + \dots + \frac{\frac{1}{P} \times \frac{r}{12}}{\frac{1}{P}} \right) \times \frac{12}{P}$$

$$= \frac{r}{12}(P-1) \times \frac{12}{P}$$

$$= \frac{r(P-1)}{P}$$

where [•] is the rate of return on deposit over *P* periods. *r* is the interest rate on deposit. The principal of deposit decreases gradually every month from (*P*-1)/*P* to 1/*P*.

(2) Compound return (*CDR*)

$$CDR=\left\{\frac{\frac{P-1}{P}\times\frac{r}{12}\times(1+\frac{r}{12})^{P-1}}{\frac{P-1}{P}}+\frac{\frac{P-2}{P}\times\frac{r}{12}\times(1+\frac{r}{12})^{P-2}}{\frac{P-2}{P}}+\ldots+\frac{\frac{1}{P}\times\frac{r}{12}\times(1+\frac{r}{12})}{\frac{1}{P}}+1\right\}^{12/P}-1$$

$$=\left\{\frac{r}{12}\left[(1+\frac{r}{12})^{P-1}+(1+\frac{r}{12})^{P-2}+\ldots+(1+\frac{r}{12})\right]+1\right\}^{12/P}-1$$

$$=\left\{(1+\frac{r}{12})\left[(1+\frac{r}{12})^{P-1}-1\right]+1\right\}^{12/P}-1$$

$$=\left[(1+\frac{r}{12})^{P}-\frac{r}{12}\right]^{12/P}-1$$

where { • } is the rate of return on deposit over P periods plus one. The principal of deposit decreases progressively every month from (P-1)/P to 1/P. Note that the reinvesting returns of deposit interests must be incorporated as the compounded return.

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