Dollar-cost Averaging: An Investigation

By

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Abstract

Dollar-cost Averaging (DCA) is a common and useful systematic investment strategy for mutual fund managers, private investors, financial analysts and retirement planners. The issue of performance effectiveness of DCA is greatly controversial among academics and professionals. As a popularly recommended investment strategy, DCA is recognized as a risk reduction strategy; however, the advantage was claimed as the expense of generating higher returns.

The dissertation is to intensively investigate the performances of DCA in light of the literatures comprehensively researched by previous thinkers. Using Monte Carlo simulation, the reviewed outcomes are confirmed by scientifically tests that DCA strategy is superior to reduce risk, but it is inferior to LS strategy in terms of effectiveness to produce returns. Although providing outperformances by investing in less volatile assets, it is more suitable to be applied for more risky investments in comparison with LS.

Contents

List of Tables and Figures

List of Figures

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It's what you learn after you know it all that counts.

Harry S. Truman (1984-1972) 33rd President of U.S.

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Chapter One Introduction

1.1 Overview

Investing is viewed by Malkiel (1996) as a method of buying assets to gain profit in terms of reasonable predictable income and/or appreciation over the long term. In a well-known book "A Random Walk down Wall Street", he (1996:28) highlighted that investment is "*a gamble whose success depends on an ability to predict the future*". However, nobody can be aware of the exact 'right' time to invest, in the light of ING's Special Report (2005:1), "Timing the market doesn't work". According to numerous researches of academics and professionals, it is found that the historical performances are not likely to be replicated and the financial market is not foreseeable. The common answer "buy low, sell high" is too simple to follow in the up-and-down financial markets. Although the concept of investment diversification benefits the investors from eliminating the non-systematic risk, it is still incapable of getting rid of the market risk. Investment advisers often must determine investment strategies to recommend to their clients so as to make the best asset allocation according to the available timing, cash size and various risk aversion levels of investors.

Dollar cost averaging (thereafter named **DCA**) is a common and useful systematic long-term investment strategy for hedge fund managers, mutual fund managers, private investors, financial analysts and retirement planners. Also known as constant dollar and pound-cost averaging in UK, it is a technique by which an investor allocates a fixed amount of money for investment at regular intervals in stocks, mutual funds or retirement plans, so as to prevent from putting a big chunk of cash with gone-up priced shares or selling with sudden and even prolonged prices-dropping panics. Market shifts is inevitable. Regardless of the market conditions, DCA, as a time-tested conservative investment strategy, is widely used by personal investment literatures as a way to increase return and avoid risk. As an alternative investment strategy to an example of DCA that an investor invests 100 pounds monthly for five years, he can plunge the entire sum of 6,000 pounds immediately, leave the investment in place and

compute the return earned on this investment over the 5 years. This strategy is called Lump sum investing (thereafter named **LS**). Its advantage is an individual can determine an optimal asset allocation; however, he may inadvertently commit all of his funds at a market high, an inopportune time to invest (Leggio and Lien, 2001).

Fundamentally, the performance evaluation of the investment strategy is from the perspective of a general risk adverse investor, given standard assumptions. Risk-averse investors who prefer dollar-averaging can accomplish the aim of risk reduction more effectively by lowering the fraction of funds invested in the risky asset and investing them all at once (Rozeff, 1994). The timing of an investment is also considered as one of the most crucial decisions made by an investor (Abeysekera and Rosenbloom, 2000). Timing investments to coincide with market performance is not a consideration for investors using DCA, due to the same amount of money is being invested at methodical and regular intervals., When it comes to investors making a sizable investment of cash in the stock market, the problem faced is to decide whether the conversion of cash should be carried out invested gradually over time or in on a lump sum. Therefore, it is important to have a deep and explicit understanding of the investment strategies and explore the effectiveness of the performances of DCA policy by means of comparing with LS strategy.

1.2 How does Dollar-cost Averaging work?

Confronting the uncertainty of the stock market, DCA is a popular investment strategy recommend by professional advisors. Rather than plunging a lump-sum amount of money headlong into the risky assets at an initial period, DCA offers an alternative to allow the investor to periodically flow the cash into market within a given time horizon. The investor with identified financial ability needs to continuously invest a fixed dollar amount on a regular basis, monthly or quarterly and make consistent purchases of stocks, bonds, or mutual funds over time. For a long-term investment, DCA requires discipline in the stock market, although it is tough to stick to the strategy due to the dicey price trends. The automatic approach purchases more units of shares when prices are low and fewer units of shares when prices are high.

The following hypothetical example is to illustrate the investing mechanism and to demonstrate the merits of DCA opposed to LS. It assumes an investment plan of £600 for a period of six month from July to December. Applying LS strategy, the individual can invest the £600 immediately in July. Investment **A** of LS makes £900 profit due to the increasing share prices; Investment **B** of LS generates £320 loss as a result of the falling share prices; and Investment **C** of LS incurs £180 loss on account of the up-and-wards prices. Therefore, the LS strategy is entirely influenced by the share price of the current investing period. Alternatively, the individual is to operate a regular monthly investment of £100 for 6 instalments, keeping the remained money in risk-free assets. The investor bought the shares at different prices over the six months. Seen from the following tables, more shares are bought with lower prices and fewer shares are bought with higher prices in contrast to the first month prices. Additionally, the individual who invested £100 per month has taken the advantage of DCA by reducing his averaging cost per share by £1.1 in rising market, £0.76 in falling market and £0.74 in fluctuating market. It is important to note that the hypothetical examples simply show the ways DCA work to favour the investors in a variety of market conditions. Presumed that investors will hold the shares in hand during the investing periods, the advantage of DCA related to unit accumulation is favourable to bring down the average cost per unit. By following a consistent strategy, it is beneficial for investors to smooth out prices waving.

Table 1.1 - Hypothetical Example of DCA Investment A

***Rising Market* - £100 per Month Investment**						
Share	**Shares Purchased For:**					
Price	**July**	**August**	**September**	**October**	**November**	**December**
£6	**16.7**					
£7		14.3				
£9			11.1			
£10						
£11				9.1		
£12						
£14					7.1	
£15						**6.7**
Total amount Invested: £600			**Average market price per share:**			£10.33
Number of shares purchased: 65			**Save**: £1.1 per share			
Average cost per share: £9.23			**Profit of LS strategy:** £900			

Table 1.2 - Hypothetical Example of DCA Investment B

***Falling Market* - £100 per Month Investment**						
Share	**Shares Purchased For:**					
Price	**July**	**August**	**September**	**October**	**November**	**December**
£6						**16.7**
£7					14.3	
£8				12.5		
£9						
£10			10.0			
£11						
£12		8.3				
£13	**7.7**					
£14						
£15						
Total amount invested: £600			**Average market price per share:**			£9.33
Number of shares purchased: 70			**Save**: £0.76 per share			
Average cost per share: £8,57			**Profit of LS strategy: -**£323			

Table 1.3 - Hypothetical Example of DCA Investment C

***Fluctuating Market* - £100 per Month Investment**						
Share	**Shares Purchased For:**					
Price	**July**	**August**	**September**	**October**	**November**	**December**
£6						
£7			14.3			**14.3**
£8						
£9					11.1	
£10	**10.0**					
£11				9.1		
£12						
£13						
£14						
£15		6.7				
Total amount invested: £600			**Average market price per share:**			£9.83
Number of shares purchased: 66			**Save**: £0.74 per share			
Average cost per share: £9.09			**Profit of LS strategy: -**£180			

1.3 The problem faced

*In personal financial counselling and planning literature, dollar cost averaging is perhaps the most recommended strategy for individuals, due in part to its **simplicity** and **commonality** of historical use.*

(Chen and Estes, 2007)

*Dollar cost averaging is an investment strategy designed to **reduce volatility** in securities…, regardless of what direction the market is moving.*

(Yahoo, 2000)

*DCA is one of the simplest, **most effective** investment strategies for building assets over the **long term**, because potentially it can turn the normal ups and downs of the markets to your advantage.*

(SYMETRA, 2006)

*The dollar cost averaging strategy is putting **volatile markets** to work for you.*

(SunLifeFinancial, 2007)

*The objective of Dollar-cost averaging is to invest gradually over time – rather than **agonize** over when to invest and then worry if you picked the **right time**.*

(Mutual of America, 2005)

Seen from the above quotes, DCA is one of the most popular investment strategies in the virtue of the several benefits. However, the issue of performance measurements of DCA opposed to that of LS is greatly controversial among a series of viewpoints from academics and professionals. A lot of researches on DCA based on comparison with LS have been conducted. They involve diversified points of view through various fashions, such as simple numerical illustrations, historical performances evaluations, simulated scenarios examinations and theoretical model discussion. There is a fierce debate going on in the field of investment from differentiated perspectives. Yet focusing on specific segments of the DCA subject, many DCA papers simply present empirical data with scant reference for how the findings advance the existing body of knowledge. The investigation in DCA strategy is deficient in terms of an analytic summation, thoroughly incorporating methodological issues, research techniques and theoretical theories. A comprehensive study is required to carry out a substantial piece of investigative work in DCA subject. Extant literature does not provide convincing evidence as to which strategy is superior (Abeysekera and Rosenbloom,

2000). A sound, laconic and critical analysis of current studies is needed to help practitioners and scholars make more explicit study directions and, apparently, help investors to make better investment decisions.

1.4 Outline of Dissertation

The study is designed to investigate on the performances of DCA from two alternative standpoints. It is significant to clearly and intensely understand the natures, applications and performances of DCA and deeply summarize momentous views in field, as the most common and simplest investment technique. What's more, it is important to scientifically test the investment strategies: DCA and LS, which will be superior to the other.

The research questions would be:

1. What are the viewpoints of scholars, supporting DCA that is inferior, superior to LS or with mixed up opinions?
2. What is the type of research performed, theoretical or empirical?
3. The standpoints and results for or against DCA have been based on what kind of assumptions?
4. How to measure DCA in terms of return and risk, which techniques or methods have been applied for empirical studies designed to investigate the strategies?
5. What are the best conditions for investors to employ DCA considering the best asset allocation between risky asset and risk-free asset?
6. The effect of psychological protection, from the point of view of behaviour finance?
7. Comparatively, what are the advantages and disadvantages of DCA over Lump Sum strategy?
8. How effective are DCA as a simplest and most common investment strategy?

1.5 Methodology

Differing from the previous studies that comparing DCA and LS by means of technical models and considerable statistical analysis with a specific researchable topic, the methodology intended to use mainly focuses on an intensive survey of the academic journals regarding to performances of DCA. Out of 40 papers approached, 27 papers closely relative to the topic were thoroughly reviewed. It is an important task due to the long-lasting controversy on the usefulness of DCA as an investment strategy compared to LS. The survey will blend conceptual literature with empirical studies. Furthermore, the methodology of Monte Carlo simulation will be applied to numerically test the literature review outcomes on ground to typical Standard and Poor 500 index, FTSE 100 Index and FTSE All-Share Index, so as to identify the effectiveness of DCA's performances based on certain assumptions.

1.6 Organization of Dissertation

Similar to the conventional structure, this dissertation begins with a general introduction and completed with a conclusion and recommendation. There are five chapters structured for the research. The initial chapter is the introduction and the remaining ones are listed as follows: Accounting for the largest proportion of the study, chapter two reviews the previous academic journals and summarizes and criticizes the momentous views in area through several sections with favourable or unfavourable views to DCA. Chapter three consists of descriptions of the database applied to assist the scientific examination and the methodology of Monte Carlo simulation opted to test the results, performances measures for evaluation and certain assumptions presumed. The successive Chapter four maps out the outcomes of the literature investigation, composing of graphical analysis and summarization of the academic opinions and particularizes the quantitative results of the comparison. In the end, Chapter five concludes the findings and recommends the limitations of the study.

Chapter Two Literature review

2.1 Introduction

There have been numerous researches conducted to examine DCA's performance, by comparing with alternative strategies, such as lump-sum investing, a buy-and-hold strategy and value averaging, the studies of which are greatly controversial. Especially, for academics as well practitioner communities, there are the divergent views on which of the two popular strategies: DCA or Lump sum **(LS)** investment to be the more desirable for the investor (Abeysekera and Rosenbloom, 2000). Splitting into three categories, this chapter provides the foundations for sorting out what has been written such as the benefits and pitfalls of the investment strategies need to consider before criticizing the extant popular literatures in the field, so as to shed a light on the deeper evaluation.

DCA as a sub-optimal investment strategy

Ever since the landmark article by Constantinides (1979), the academic literature has been decrying the inefficiency of DCA (Mileysky and Posner, 1999). Although Constantinides (1979) acknowledged DCA's ability to reduce the risk of investing but still regard it as a sub-optimal investment strategy through two propositions. Williams and Bacon (1993) compared the annual returns from various DCA strategies with that of LS and conclude that LS produced superior returns to DCA for all time periods. Rozeff (1994) noted that LS policy is superior to DCA, because LS makes the invested funds to experience more independent return realizations and gives a greater assurance of obtaining the expected return with lower variance, concerning different time horizon. What's more, Atra and Mann (2001) stated the desirability of investing through dollar-cost averaging is heavily influenced by the seasonality of equity returns.

DCA as an investment strategy with mixed opinions

Additionally, there are some mixed opinions on the issue of DCA performances. For example, Atra and Mann (2001) test the DCA and LS by several international indices

as opposed to domestic equity investments and suggest that DCA may be a superior strategy depending on when it is implemented; conversely, LS may be a superior strategy depending on when it is implemented. T

DCA as an optimal investment strategy

Weston (1949) analysed the difficulty in forecasting the accurate prices of stocks which have given birth to formulae plans such as DCA, which takes advantage of the fluctuations in prices over a period of time. Dubil (2005), whose results achieved through a Monte Carlo simulation, stressed that DCA has risk-reducing benefits over LS and '*The level of risk reduction depends on the length of the averaging relative to the total saving horizon*." In addition, Statman (1995), who introduced a behavioural finance argument for the existence of DCA, has claimed that DCA may not be consistent with standard financial theory, but instead is based upon investors not wanting to experience "'regret'. It implies that investors may use DCA to avoid seeing their entire LS experience a poor return. A behavioural rationale is not the only explanation as to why investors might choose a DCA program. (Atra and Mann, 2001) Also, many individual investors select DCA as retirement plans. Flangon (1992) recommends DCA to retirement investors as an option of benefiting from market movements while at the same time restricting from risk of losses. Tacchino et al. (2005) advice DCA to their clients as one out of ten commonly accepted retirement investment strategies as well.

2.2 The Academic view on DCA and LS

2.2.1 Literature of studies, showing LS is superior to DCA

Constantinides (1976) summarized two properties of DCA investment policy on the perspectives of Malkiel 1975 and Cohen et al. 1977 and a simple example of hypothetical investment opportunities. He showed concerns regarding the natures of DCA with relevant time horizon, regarding it as a nonsequential investing behaviour, in contrast to sequential investment policy which may be interrupted by a sharp market decline and investor psychological factors. According to his example, DCA was defined to depend on the composition of the investor's wealth. He stated that the

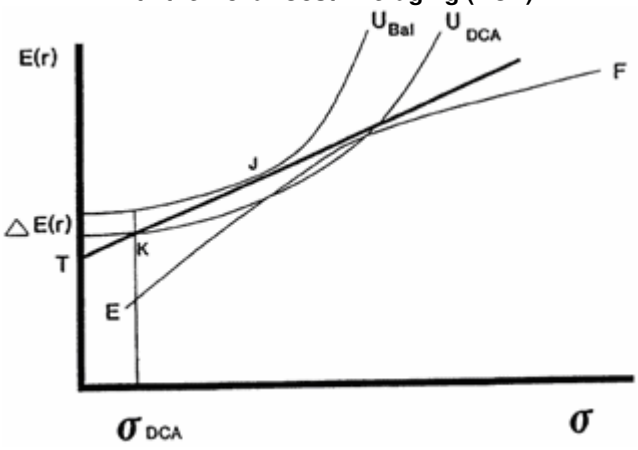
rationale behind DCA scheme, which shifts the major gamble into a number of smaller ones to spread risk, was questionable. He assumed the underlying assets to be invested in a standard perfect market: investor as a price taker; no personal tax; and no transaction costs with further standard economic assumptions: e.g. maximized expected utility [1] of consumption, to dodge the unnecessary issues of DCA. Constantinides derived two propositions to criticize the inferiority of the investing policy using expected utility function. First of all, he specified that DCA is dominated by sequential optimal investment policy. It is regardless of future information, which "*will not coincide with the optimal sequential policy at all future times*" (1976:444). For example, the nonstationary policy may benefit the new information in an uptrend stock market. Secondly, he inferred that DCA is dominated by an optimal non-sequential investment policy. According to his illustration by models, "*an optimal nonsequential policy is invariant to the composition*" (1976, 447), on the contrary, DCA was defined to depend on the composition of wealth. Due to his inferences, DCA was concluded as an inferior investment strategy. Furthermore, based on the study by Pye (1971) that optimal nonsequential policy is not gradual, Constantinides regarded DCA, "*a usually (but not necessarily) gradual policy*" (1976, 447), as suboptimal policies.

Knight and Mandell (1993) compared DCA investment system with two investment tools: Optimal Rebalancing (OR) strategy and Buys and Holds (BH) strategy. The objective of this paper was to disapprove the best known benefits of DCA: augmented returns by lower prices shares bought and avoiding the risk of unfortunate timing for LS investing. They presumed that investors have an initial amount of wealth invested in the underlying riskless assets and know the balance between risky and riskless asset for optimized utility, which is 50-50. Firstly, they explored that the DCA investment strategy experiences utility loss in comparison with OR strategy, which was illustrated by graphical analysis ignoring the level of investors' risk aversion (Figure 2.1).

[1] Utility function assumes that investors can assign a welfare or "utility "score to any investment portfolio depending on its risk and return. (Bodie et al. 2005: 165)

Figure 2.1[2]

The Optimally Balanced Investor (Bal) compared With the Dollar Cost Averaging (DCA)



Secondly, they empirically compared the certainty equivalent[3] wealth difference and certainty equivalent return between the three strategies by means of Monte Carlo simulation. Incorporating the Wiener process, they established a utility function model based on the theory of Merton (1969) for both risky and risk-free asset. Using the New York Stock Exchange data as parameters, they measured the expected utility of wealth for investors with various degrees of risk aversion[4] provided by 500 draws from the simulated stock market. Therefore, they argued that the result of DCA in three strategies was "*consistently and substantially*" (1993, 57) below that of the other two strategies. Furthermore, they empirically measured the strategy performance using historical monthly returns of S&P 500 and Treasury Bills from 1962 to 1992 with high, moderate and low three degrees of risk aversion. They found that DCA "*yielded the smallest annualized return and mean utility*" (1993, 59). What's more they assumed that transaction costs would decrease by larger investment size and would increase by more frequencies of investment. Thus, under this assumption, they claimed that more costs will be added to DCA compared with the other investment strategies, which worsens the performance of DCA. According to their theoretical arguments and numerical evaluation, Knight and Mandell (1993) concluded that DCA is a convincingly under-performed investment strategy in contrast to OR and BH strategies.

[2] Source: Knight and Mandell (1993)

[3] Certainty equivalent rate of a portfolio is the rate that risk-free investments would need to offer with certainty to be considered equally attractive as the risky portfolio. (Bodie et al.2005:169)

[4] Risk –Adverse investors are willing to consider only risk-free speculative prospects with positive risk premium. (Bodie, 2005: 168)

As explicitly stated that "Those who hesitate, lose", Rozeff (1994) claimed that a lump-sum investment policy dominates the dollar-averaging, or spreading a risky investment out over time. He was in disagreement with certain investment literatures, which supposed dollar-averaging to reduce variance without sacrificing return (Black and Scholes 1974 and Smith, Proffitt and Stephens 1992). He considered the stock market with a positive expected risk premium, which meant that the market was of a constant upward tendency. In order to approve his arguments against DCA, Rozeff compared the two investing policies by a generalized two-period example and further T periods formulas, with the assumption that returns of two strategies follow a random walk model and are multivariate normal. Using Markowitz's (1959) classic mean-variance approach, he provided hypothetical illustration in terms of variance and mean returns (expected terminal returns). Firstly, he assumed equal investment in DCA and LS which produce unequal returns that DCA offered less expected terminal wealth than LS does but less risky (lower standard deviation). Secondly, correct risk adjustment was made to allow 'a clear-cut and fair comparison' by reducing the amount of invested risky asset in LS policy. Thus he adjusted LS and DA with equalization of returns, which resulted in greater standard deviation in DA approach. Likewise, if adjusts same standard deviation, LS policy provided greater expected terminal wealth. Furthermore, Rozeff tested his results by computational simulation, which applying real data of monthly S&P 500 Index and small-firm portfolio from 1926 to 1990. Returns and standard deviation of DCA and LS over intervals, the ratios between them and the Z-statistics were computed for comparison, which show that LS policy with risk-adjustment outperformed DA policy. Through these results, Rozeff concluded that, compared with LS, DCA is inferior and mean-variance inefficient, which let the investments in the risky asset experience less independent return realizations, due to the weaker assurance of obtaining the expected return with lower variance.

Thorley (1994), whose study investigated the effectiveness of DCA, challenged the conventional wisdom that investors can benefit from DCA strategy subject to avoiding the risk of investing a large amount of money at an inopportune time and increasing returns by the lower average cost of shares compared with the average price. Firstly, he illustrated the misconception of the latter point by a concise mathematical example. He claimed that the lower average cost may be likely but not certain and "*DCA*

performs well under a seemingly plausible but irrelevant criterion" **(1994, 139)**. As he argued, the most significant value to investor was the final return of the investment, rather than that was contingent to be calculated by the average historical cost of shares for the investors who are merely to clear their accounts at current prices. Secondly, he empirically examined the performances of averaging investing including both DCA and value averaging with a result of lower expected returns and higher risk compared with the benchmark buy-and-hold strategy. His examination was under the assumption that, in a perfectly random or efficient market, the return was calculated by Internal Rate of Return (IRR) of the investment cashflow and ignores the return on cash not invested, using the original data of S&P 500 Index and Treasury bill for the period 1926-1991 from *Ibbotson Associates'1992 Yearbook*. Furthermore, due to the previous evidence, he considered the situation of non-random price changes, such as the stock prices with mean reversion and price change momentum over short horizons. Accordingly, his results showed that the averaging strategy is still suboptimal to the benchmark. In addition, as the result of 66 historical observations of DCA returns, Thorley measured the constant rate of return, unbiased estimate of future return, risks, portfolio adjusted risks and strategy's beta in terms of geometric mean, arithmetic mean, standard deviation, beta, Sharpe's Measure and Treynor's Measure. With the results obtained by first order approximations, he concluded that, compared to LS strategy, the favour of DCA is a fallacy that "*Dollar Cost Averaging has no value and may actually be harmful as an investment strategy*" **(1994: 142)**.

Bacon, Williams and Ainina (1997) considered the long-term performance of DCA policy in the bond market. Their study was to explore the effective investment strategy for the investors with a large sum of endowment and certain level of risk aversion. The objective was to empirically examine the conventional wisdom of DCA such as risk reduction by comparing with investing all the funds at once, so as to fill the gap in the field of bond market in the literature. They used the data from Ibbotson Associates 1996 Yearbook comprising monthly rates of return for Treasure bonds, corporate bonds and 90-day Treasury bills from 1926 to 1995. Assuming that an overall return consisting of the income and the capital gains returns, they compared the two investing policies based on historical evidence. Firstly, they exemplified that, from January to December 1993, the annual holding period return (AHPR) of LS strategy was higher than that of a 12-month DCA policy. The returns by DCA were making up

of returns gained from corporate bonds and interests accumulated from Treasury bills. Furthermore, the investigation was extended to more DCA investment categories with two averaging periods: six-month and three-month. They compared the historical average annual returns of LS and DCA strategies from the annualized return, standard deviation and Sharpe Index three dimensions. As a result, investing immediately provided the higher return than averaging investment through time; additionally, they found that the less the number of the DCA instalments is, the higher the return it generates. Although the statistics of standard deviation illustrated that the risk reduction by DCA policy, the advantage was controverted by the result of Sharpe Index, as "*the higher Sharpe Index implies superior risk-adjusted performance*". Finally, they concluded that LS strategy is likely to be the superior one as opposed to DCA policy, though the latter favours the investment decision making due to the psychological benefits.

Marshall (2000) examined the investment performances of three investment techniques: Value Averaging (VA), Dollar-cost Averaging (DCA) and Random Investment (RI), by means of internal rate of return (IRR). Moreover, they noted that efficient market hypothesis (EMH) can not work in DCA and other purely mechanical techniques, since investors may initial the investment techniques at different levels of stock prices and the benefits of the techniques should vanish as more and more investors would engage in the market to take the advantage of optimal technique. Firstly, Marshall provided numerical comparison of the average prices, average costs and IRRs between DCA and VA with assumed rising, declining and fluctuating trends of stock prices over time. He claimed that, in spite of VA with a lower average cost of shares and higher IRRs than DCA, it was insufficient to testify the advantageous performance over DCA, on account of more significant terminal investment return and associated risk. Secondly, he continued the three-way comparison among strategies by employing 500 simulations of investment results over time to calculate mean return and standard deviation of the IRR and F-Test to test the variation among the IRRs, under the assumption that ignores the transaction cost and taxes. The data of S&P 500 index variability with five year (20 quarter) investment time horizon was randomly selected for the period from January 1st, 1966 to March 31st, 1989. Accordingly, he explore that the performances of VA dominates that of DCA and RI of all the 13 tests and 73.5% of all simulations without "*statistically meaningful difference in risk*" (2000,

97) among the three techniques and DCA performs equally to RI regarding to Marshall and Baldwin's (1994) previous research. Lastly, he conducted a final test based on historical evidence rather than theoretical tests and found out that VA generates higher IRR than DCA and RI over the entire periods, ignoring the return available from temporary investments in the side funds and inherent risk reduction in a money market fund. Thus, Marshall concluded that VA does outperform than DCA and RI for higher expected returns without additional risks.

Vora and McGinnis (2000) analysed the better asset allocation decision making from the perspective of retirees, by applying the underlying concept of DCA investment strategy. In order to carry out their empirical comparisons between stocks and bonds portfolio investments, they followed the viewpoints of Constantinides (1999), Knight and Mandell (1993) and Rozeff (1994) on the fallacy of DCA strategy, assuming that DCA is inferior to LS investing into stocks and "*retirees are interested in maximizing their consumption stream*". They proposed the concept of "*dollar cost disinvesting*", as a converse DCA strategy. They sourced real monthly return data on the Canter for Research in Security Prices' (CRSP) Value Weighted (VW) portfolio and the monthly holding period returns on an equally weighted T-bond, long-term AAA- and Baa-rated corporate bonds portfolio from CRSP for a period of 70 years from January 1926 to December 1995, which covering assorted fluctuations and movements of stock prices and interest rates. By modelling simple formulations, they calculated the dividends and capital gains and the equal monthly consumed amount of money for retirees, considering transaction costs, taxes and consumption risks. Throughout all the qualified evidences, Vora and McGinnis (2000) concluded that a stock portfolio provides higher consumption than a bond portfolio and the likelihood is proportionate to the time horizon. As noted, in the case of retirement plans, investors are advised to put money into stocks but better off 100% equity investing.

The study of Scherer and Ebertz (2003) was to establish an approach to theoretically evaluate the performances of cost averaging method. They supposed cost averaging as a dynamic strategy, which is defined as "*dynamically varying between equity and cash with a fixed rule*" (2003, 188). Firstly, they claimed the 'misleading' of the approaches that used to testify the optimality of cost averaging, including immeasurable performances due to the non-predictable property of the investment

return series, predefined statistical risk measures with ambiguous results and investor's utility function lacking general uses. Secondly, using state price deflators as valuation method and a standard Brownian motion, they noted that "*it is more expensive to buy a contingent claim that pays one monetary unit*" in a upward stock market rather than in a downward stock market, under the assumptions that the expected rate of returns is higher than the risk-free rate, every state of the world equals likely and utility is a concave function. After that, Scherer and Ebertz (2003) argued the application of payoff distribution pricing model concerning the dynamic asset allocation strategies and claimed that the cheapest portfolio will exit if the terminal wealth does not fall with rising state price deflators. Lastly, they undertook the foregoing models and theories to evaluate cost averaging using simulation and graphical comparison with the valuation of European call, equity and bond. Lastly, they concluded that "*cost averaging is inefficient*" (2000, 192) and refuted the argument that cost averaging is advantageous in volatile market, but on the contrary, the higher the volatility levels, the larger the inefficiency costs of averaging cost.

The study of Johnson (2004) had been presented at the 2004 Academy of Finance Annual Meeting, which was submitted for publication the same year in the Journal of the Academy of Finance. The objective of the author was to explore the effect of market timing for both investors and financial planner and investigate the performances of DCA as an alternative investment strategy to LS strategy. The research had a data set of 5050 trading days' daily S&P 500 returns from 1st January 1981 to 31st December 2001 for a period of twenty years from Economagic.com, which involved the unequal "*advancers and decliners*" (2004, 3) similar to the reality. Applying Kurtosis measured by their sample statistics, he states that the data indicates "*a much sharper peak for losers than for winners*", which included the worst investing period in October of 1987. To focus on the central issue of DCA and avoid any potential complexity, they assumed dividends be excluded from returns calculation. Firstly, he attempted to empirically analysis the effect of missing different number of the best and/or worst investment days in terms of compound annual return, daily return, standard deviation and risk-adjusted return. Thus their results showed that market timing could be detrimental as well as beneficial to the investment, which doesn't work for the investing decision-making. In addition, he examined the DCA strategy, which ignored the market timing as the contrary. He considered monthly and

quarterly periodic investment instalments with the data set of S&P 500, NASDAQ Composite Index, Dow Jones Composite Index, Dow Jones Utility Index, 30-year T-Bonds and baa Long-term Bonds for the same period 1982 to 2001 by using of hypothesis test. Except NASDAQ Composite Index, the results favoured LS strategy. What's more, the quarterly periodic investment produces better results than monthly one, which meant that the smaller the number of investment instalments is, the higher the return the investment strategy produces. However, all the results were based on the assumption of the dividends, which had different impact on the returns of DCA and LS. As a result, he concluded that DCA as an alternative strategy to investing by timing the market is inferior to LS strategy, which was suggested to employ as large as possible.

Theoretically, the proponents of the conventional wisdom (Asinof 1991, Clements 1992, Malkiel 1991 and Smith, Proffitt and Stephens, 1992) recommended the benefits of DCA to avoid the risk of investing the entire amount at a wrong time including producing a lower average price per share and a presumable higher realized rate of return. The objective of William and Bacon (2004)'s research was to empirically examine the effectiveness of DCA and LS investment strategies, comparing their annualized returns based on historical data. For one thing, they assumed the investment initially invested in Treasury bills, which involved the accumulated interests of the risk-free asset during DCA spreading its investing funds. Also, they ignored the taxes and transaction costs. William and Bacon (2004) applied monthly total rates of return for the Standard and Poor's 500 Stock Index and 90-day Treasury bills from 1926 to 1991. Firstly, by use of the AHPR (Annualized Holding Period Return), a computational example using data of January-December 1988 illustrated their basic approach for the comparison. Secondly, they analyzed the data of return from different DCA strategies, which invested in one-month, three-month and six-month DCA instalments, through 1926-91, 1950-91 and 1970-91 three periods; especially, the third investment period 1970-91 covered both bull and bear market.

Figure 2.2[5]

Annualized Returns from Lump-Sum and Dollar-Cost Averaging Strategies for Various Periods

	Mean Return	Standard Deviation
1926–1991		
Lump Sum	12.75%	22.81%
12-Month Averaging	8.50%	13.21%
6-Month Averaging	9.97%	16.81%
3-Month Averaging	11.14%	19.40%
1950–1991		
Lump Sum	13.37%	16.39%
12-Month Averaging	9.63%	9.83%
6-Month Averaging	10.97%	12.91%
3-Month Averaging	12.00%	14.61%
1970–1991		
Lump Sum	13.28%	16.84%
12-Month Averaging	10.80%	10.56%
6-Month Averaging	11.84%	13.80%
3-Month Averaging	12.51%	15.40%

Figure 2.3[6]

Lump Sum Versus Dollar-Cost Averaging

	Percent of Time LS Exceeded DCA
1926–1991	
Lump Sum vs. 12-Month DCA	64.5%
Lump Sum vs. 6-Month DCA	62.4%
Lump Sum vs. 3-Month DCA	60.5%
1950–1991	
Lump Sum vs. 12-Month DCA	66.3%
Lump Sum vs. 6-Month DCA	63.2%
Lump Sum vs. 3-Month DCA	62.2%
1970–1991	
Lump Sum vs. 12-Month DCA	59.5%
Lump Sum vs. 6-Month DCA	56.7%
Lump Sum vs. 3-Month DCA	57.5%

They found "*the fact that the returns for dollar-cost averaging increase as the number of DCA instalments is reduced*". Additionally, by use of the tables, they summarized the proportion of the 65 years of LS strategy outperformed DCA, which was nearly two-thirds of the whole time. Furthermore, using T-test, they measured the difference between DCA and LS in the mean annualized returns with significance at the .005 level, whose results strongly supported the superiority of LS over DCA policy. Through those results, William and Bacon concluded that, although without the assurance of the past pattern of investment strategies will persist in the future, DCA is inferior to LS. Thus, they advised investor to invest the entire amount immediately instead of gradually shift the funds into market.

Chen and Estes (2007) examined the performances of DCA and Value averaging (VA) in the framework of 401(k) retirement plans. Due to the property of VA that maintaining an average investment value, they compared two strategies following the concern of Marshall (2000) and Leggio and Lien (2003) on the issues of adequate outside reserves. Firstly, they noted that the changes of standard deviation of returns differ from that of the standard deviation of terminal values regarding to the changes of time horizons. Thus, throughout their analysis, dollar returns were applied instead

[5] Sources: William and Bacon (2004)
[6] Sources: William and Bacon (2004)

of the infeasible returns. Secondly, they used Monte Carlo simulation to measure the performances of them based on historical monthly return data, which consisted of Treasury bills and S&P 500 index for a period of past 70 years. Moreover, they considered a simpler sample within a volatile period from 1950 to 1980 involving Korea and Vietnam wars and worldwide oil shocks. By means of 5,000 simulations, they found similar results as Abeysekera and Rosenbloom (2000) and Marshall (2000). For one thing, in terms of mean terminal values, DCA outperformed VA strategy with a growth target rate that lowers than 8 percent. But their data revealed that VA for 401 (k) was superior to DCA investing by higher terminal value, even without capital reserves. Then, they testify the performance in terms of total risk levels and explored that "*at an annual growth target of 12 percent (1 percent monthly), the total risk from the 401 (k) VA strategy is still lower than that from the DCA strategy*". In addition, they compared the DCA and LS on the basis of modified Sharpe ratio and modified Sortino ratio that applying dollar returns rather than an expected return and found that the DCA strategy had a worse risk/reward trade-offs than the 401(k) VA strategy. From their empirical researches, Chen and Estes (2007) concluded that DCA underperforms than LS strategy for 401 (K) retirement plans for the investors which have the annual target growth rates more than 8 percent and less than 12 percent.

2.2.2 Literature of studies, having a mixed opinion about DCA and LS

Pye (1971) discussed dollar averaging in terms of minimax policies. He noted one significant effect of dollar averaging in the financial markets is to deal with the uncertainty. He theoretically analysed the dollar averaging investment strategy through examining nonsequential policies and sequential policies using relative formulations. He assumed that there was a given amount of money to be invested into stocks within a given spreading periods and the stock prices followed an arithmetic random walk. As claimed that "*hedging against large regrets or opportunity losses*", he upheld the psychological benefits of dollar averaging with respect to the effect of a regret criterion in personal investment decision-making, but highlighted that the strategy was short of "*hedging against unfavourable outcomes*". Through the using of

a variety of formulations, he demonstrated that "*dollar averaging is a nonsequential minimax strategy*", which is independent on the behaviours of stock prices, if there were equal possibilities for both positive and negative largest price fluctuations. In addition, he disputed the ability of dollar averaging to maximize the expected utility as a nonsequential investment strategy for "*any strictly concave utility function*" under the assumption of arithmetic randomly walking.

For the *Journal of Portfolio Management*'s twentieth issue, Samuelson (1994) carried on the debates of micro-efficiency and macro-efficiency of general market. In this paper, his purpose was clearly titled to analyze "*the long-term case for equities*". Except his explanation on the possible superior performances of asset allocation and investing timing, he critically discussed the Buy and Hold (BH) investment strategy for long-run equity investors. Throughout the theoretical arguments, he noted an important point with respect to DCA strategy. As wittily claimed that "*sleeping well for irrational reasons, is as good as sleeping well for rational reasons*", Samuelson (1994) diminished the advantage of DCA over LS investment strategy as Statman (1995) claimed, which benefit the irrational investors suffering from psychological problems of investing regrets and self-control.

Braselton et al. (1999) examined the investment performances of DCA and LS strategy using mathematical approaches. Their researched complied with the concept of random walk of stock prices, which argued that it is not likely to estimate the price drift according to historical changes and also difficult to predict the 'right' investment timing. They tested the strategies performances using the data of the daily closing values of the S&P 500 index for a period of 68 years from January 1, 1926 to June 11, 1993 sourced from the Internet. A total of 17,610 values were employed to operate the calculations. They performed a variety of mathematical tools and computational techniques, such as *Mathematica*, DataManipulation package, ToExpression, DropNonNumeric, ListPlot, ContinuousDistributions and dcaVsLumpSum to compute the dataset, generate the function histograms and analyse the statistics using Logistic model. Accordingly, they empirically evaluated the numbers achieved by simulating the behaviour of the stock market 500 times for each time horizon as the S&P 500 Index for 54 months. As a result, they measured the performances of DCA and LS in terms of mean and standard deviation for 1-year, 5-year and 10-year separate time

horizons and constructed histograms to representing the data based on an assumed scenario. Though they presumed that DCA has the advantage of risk reduction, they regarded the property of DCA that requires investors spreading investment funds periodically as a disadvantage of inflexibility. They assumed that investors have the initial amount of money to invest and calculated the number of shared purchased each month, the overall number of shares gained, total values of the investing and earning of the investment. Throughout all the illustrations and empirical evidences, they claimed that "*if the funds are available, lump-sum investing can be expected to produce substantially higher returns than dollar-cost averaging*".

Abeysekera and Rosenbloom (2000) were to seek for the superior investment strategy between LS and DCA strategies for an investor, by means of a Monte Carlo simulation model. The objective of this paper was quite clearly "*to demonstrate that the choice between DCA and LS strategies must be based on the distributional properties of the outcome expected by the investor at the time of initial investment*". Firstly, they modelled the movements of stock prices and riskless interest rates by a lognormal distribution. They employed the data of monthly returns of the S&P 500 index between 1926 and 1997 and Treasury bill rates between 1934 and 1998 as proxies for simulation. They presumed that there is an initial sum of funds to invest; T-bill rates followed a random walk over a one-year period; monthly stock market returns were independent; the parameters of the lognormal distribution were constant and the expected return of the stock exceeds the risk-free rate. A 1000-replication simulation was carried out to estimate the distributions of the terminal value and its differences of LS strategy and DCA strategy.

Figure 2.4[7]

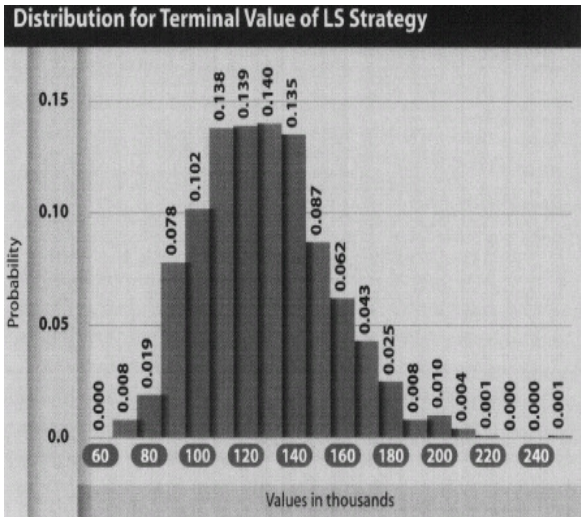
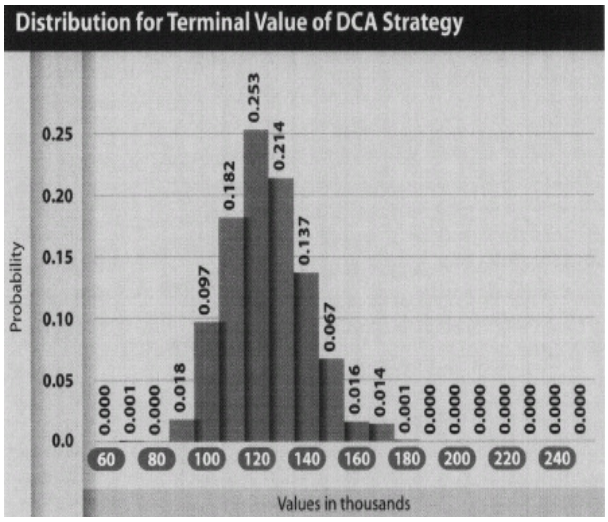


Figure 2.5[8]



With respect to various initial risk-free rates and different expected returns of securities, they considered different scenarios to explore the relative frequency of LS outperforming DCA and the mean percentage difference between LS and DCA strategies by the simulation model. Thus, they found that DCA will under-perform LS in most of the strategies, especially for the low volatility assets. However, as they stated, "*the chances of the LS strategy outperforming the DCA strategy decrease as volatility increases*". Moreover, they claimed that there is greater risk with the LS investment strategy compared with the DCA strategy, although with higher mean return. Regard to their empirical illustration and simulation analysis, they concluded that it is very misleading to state that one strategy is necessarily superior to the other one. According to that LS generates higher returns but with higher investing risks and DCA produces lower returns but with lower risks, the decision between the two strategies should be measured by the reward/risk trade-offs from the own perspectives of investors.

The study of Atra and Mann (2006) was stated to provide additional insight for the controversy between DCA strategy and LS strategy from the perspective of performance measures over different periods of time. They noted that it is difficult to compare the returns of the investment strategies on account of the various timings of the funds invested. Thus, approaching the above problem and adhering to the concept of Sharpe (1994), they applied a self-financing portfolio, which is composed

[7] Sources: Abeysekera and Rosenbloom (2000)
[8] Sources: Abeysekera and Rosenbloom (2000)

by funds borrowed at risk-free rate and invested in risky securities and allows the comparison between strategies on a reward/risk basis. Ignoring transaction cost and tax, they assumed that the remaining money of DCA strategy was temporarily invested in risk-free assets and presumed that DCA strategy and LS strategy were completely financed with borrowed funds in the context of self-financing portfolio. The research was based on historical data of monthly total return that sourced from Morgan Stanley Capital International for a range of international indices from 1970 to 1998 and risk-free rates that estimated using U.S. 90-day Treasury-bill rates. Firstly, with respect to their entire sample results, they noted that DCA produces slightly higher returns than LS, through not significant. Secondly, their replicated 29 times monthly return results demonstrate the existence of "good season" and "bad season" for separate investment strategy. They claimed that October to January are the best period for LS and November and December are significantly good timing to initial LS investing; February to September are the best time for DCA and May and June offers particular superior returns by DCA strategy. Furthermore, a risk-adjusted measure – Sharpe ratio was employed by Atra and Mann (2006) to identify the more desirable investment strategy. However, not in conform to the conventional wisdom, they found that DCA produces both higher returns and higher risks. In addition, they explored that in the concept of seasonality, all the international indices indicate similar tendency and the U.S. stock market is the least sensitive to use alternative strategies, as well as by use of the Sharpe ratio. Through all the empirical illustration and analysis, they concluded that "*DCA investing offers no benefit in terms of a reward/risk trade-off*" and the choices between LS and DCA should incorporate the seasonal timing patterns of the stock market.

From the perspective of the Statman (1995)'s behavioural rationale, Leggio and Lien (2001) examined the relationship between DCA policy and investors' loss aversion preferences by comparing with alternative investment strategies: Lump-Sum (LS), Buy and Hold (BH) and Value averaging (VA). The data of the monthly returns for a period from 1970 to 1999 were sourced from Ibbotson and Sinquefeld (2000) for empirical researches, including underlying risky assets: large company stocks (S&P 500 Composite) and Ibbotson small company stocks and underlying risk-free asset: U.S. T-Bills for not invested DCA funds. As an alternative to expected utility theory that evaluated the decision-making from the view of risk-aversion for the total

investment wealth, they employed the methodology of prospect theory proposed by Markowitz (1952), which evaluated the decision-making based on both potential losses and gains by S-shaped value function (curve concave for gains and curve convex for losses). Leggio and Lien assumed the investors with constant relative risk aversion the same as Markowitz and there was a fixed sum of funds available to invest within one year time frame. Their results of 30 observations showed that "*the mean excess returns for DCA are always below the mean excess return for LS investing*", regardless the underlying asset. Moreover, they explored the mean-variance inefficiency of DCA. Their empirical results showed that higher mean portfolio return and lower standard deviation of BH than that of DCA, which contradicted to the property of the expected utility function: the higher the return, the more risky the investment. Likewise, by use of the S-shaped utility function, LS and BH generated higher value functions than DCA's for both large and small company stocks. They also examined DCA is sub-optimal to LS in terms of Sharpe ratios and p-value, especially for small company stocks with higher volatility. Finally, they summarized that "*Investor utility is lowest for a DCA investment strategy for relatively volatile assets such as small cap stock, and is inferior to all investing strategies except value averaging for large cap stocks*".

The objective of Leggio and Lien (2003)'s paper was to observe the performance of DCA policy in contrast to the alternative investment strategies: Lump-Sum (LS) and Value averaging (VA). The criterion was the higher the ratio, the larger the investment reward for bearing risk. As not content with Sharpe ratio as the sole investing risk measures, they took into the account of risk-adjusted measures: the Sortino ratio and the upside potential ratio **(UPR)** as alternative tools. They argued that Sharpe ratio which is "*the excess return per unit of standard deviation*" was an inappropriate measure, due to "*standard deviation of returns captures both positive and negative variation from the mean*". They claimed that the real risk for investors is that the variations from the negative mean rather than the variations from the positive ones. Thus they employed the Sortino ratio referring to the "downside risk" by excess returns measures and UPR regarding the upside potential risk by positive excess returns measures. The investors were presumed to have a fixed sum of funds available to invest with one-year time frame initially. The remaining money of DCA was assumed to be invested in U.S. Treasury bills and the investment portfolios

incorporated both risky assets and risk-free assets: large company stocks (S&P stocks composite), Ibbotson small-company stocks, long-term government bonds and long-term corporate bonds. Their study on DCA and the alternative strategies were concentrating on the empirical test based on historical evidence. They applied the data of monthly returns for 1926-1999 and 1970-1999 two periods, which come from the *Ibbotson Associates Valuation Edition 2000 Yearbook*. From the statistics analysis, they claimed that the ranking results of the Sharpe ratio is contradicting with that of the Sortino ratio and UPR. With the obtained results, they concluded that DCA is not supported to be optimal by use of the Sharpe ratio and DCA is still inferior using the more accurate performance measures: the Sortino ratio and UPR.

The purpose of Milevsky and Posner (2001) paper was to model investment funds allocation between a risk-free and risky asset based on a geometric Brownian motion (GBM) and the fashion of continuous-time finance response to the complement of Statman's (1995) behavioural theory and the performance examination of DCA in contrast to LS strategy. Their primary interest was not in the comparison between two investment strategies but in explaining that applying a DCA strategy is similar to purchasing a zero strike arithmetic Asian option, which is a popular derivative on the underlying security. The departure point for the demonstration was to set the denoted GBM model, which contributed to the stochastic value of DCA portfolios and allowed the use of stochastic calculus techniques. They assumed an initial amount of wealth available to invest and the interests earned by each portion of not invested funds (also can be zero), which will reinvest in the underlying stock with time value adjustment. They summarized that "*The end-of-period stochastic payoff from dollar-cost averaging is identical in distribution to the stochastic payoff from a zero-strike arithmetic Asian call option. This identity implies that a rational individual would be indifferent between dollar-cost averaging and purchasing a zero-strike arithmetic Asian call option on the underlying stock.*" Furthermore, they examined the expected conditional payoff of DCA opposed to LS, with the assumption that knowing the final fixed value of the underlying security which still in stochastic process and "*strongly path-dependent*". In contrast to GBM, they applied the tool of a standard Brownian bridge, which "*fixed at both ends*", to analyze the conditional expected payoff from DCA. Additionally, within the framework of continuous-time finance, they reviewed the mean-variance inefficiency of DCA strategy in terms of expected value and standard deviation in

contrast to buy-and-hold portfolio, using numerical example and risk-adjusted analysis by Sharpe ratios. Through these analyses, maintaining the stochastically dominated position in mean-variance framework of DCA strategy, they concluded that DCA with certain volatility produce a higher conditional expected value than LS, the benefit of which increases with higher levels of volatility. Moreover, they highlighted the consistency between the conditional expectations and behavioural explanation.

Bierman and Hass (2004) analyzed the performances of DCA policy compared with LS investment strategy by both critical arguments and numerical evaluations. They made the differentiation of the generated investment funds between 'currently available' and 'additional through time'. They claimed that investment funds through time were likely to be favoured by DCA, but the prerequisite is that funds need to be invested in the "*not too high*" market by diversification, which pruned off the advantage of DCA. Their literature studies involved both 'for' and 'against' perspectives of the scholars, among which much attention had been paid into the behaviour considerations of DCA. Bierman and Hass stresses DCA's initiative role in bringing psychological analysis into the debates of investing policies' effectiveness. They highlighted that the reduction of investors' regret should be on account of diversified investing rather than benefiting from DCA in "*a stable or rising market*". Assuming expected return of the stocks higher than the cost of equity, they pointed out "*DCA does not reduce the expected return or increase the investor's risk in a normal situation*" by "*delaying the balanced portfolio*". In addition, they claimed that DCA could, be more desirable if the expected return of the equity equal to its cost, since "*delay does not have a cost*". With regard to the reducing risk of DCA, they stated that the conclusions consist with the assumptions of the delaying cost. As a result, Bierman and Hass concluded that DCA is more favourable in downward stock market and less favourable in upward stock market; however, no matter the investment funds are currently available or to be received through time, DCA is not advocated compared with immediate investing, though, which may mitigate behavioural investing problems.

In the paper, Brennan et al. (2005) claimed that, DCA as a widely recommended investment strategy, whose heuristic property had been overlooked by scholars and professionals with the perspective of irrational investing behaviour. Concerning its

heuristic value, they attempted to examine the performances of DCA portfolio and alternative purchase strategies, such as Lump-sum (LS) and Buy and Hold (BH) by comparing their yielded certainty equivalent wealth levels. For one thing, they focused on the stock prices behaviours regarding to the random walk hypothesis, rather than the issues of behaviour finance, such as 'self-control' and 'confidence' of investing. For another, they took into account the practical manipulations for individual investors and the heuristic value generated through DCA approach for investors not complying with standard asset pricing models. Assuming that transaction costs and market impacts ignored, they empirically analyzed and examined the usefulness of DCA strategy in contrast to LS and BH for "*an investor whose objective is to maximize the expected value of a standard von Neumann-Morgenstern utility function defined over wealth*" by means of Monte Carlo simulation. They evaluated the value of the DCA heuristic taking the account of random selected stock prices within a total securities number of 25,396, firm market values, 30-day T-bill rate as risk-free interest rate and market portfolios including the CRSP Equal Weighted Market Portfolio and CRSP Value Weighted Market Portfolio, whose data was sourced from CRSP database for a period from December 1925 to December 2003. The simulation method was applied with respect to different levels of risk aversion with the time horizon from 12 months to 72 months. Firstly, they considered an investor with a diversified investing portfolio and found that DCA is superior to LS aside from the investors with the lowest risk aversion, due to the strategy's intrinsical lower risk property. But both of them were dominated by a 50% stock and 50% cash monthly rebalancing method. Secondly, they claimed that DCA has overwhelming out-performances compared with LS for the inefficient single stock investment, regarding to its lower risk characteristic again. Thirdly, they shifted the foremost attention to the research of the usefulness of DCA strategy on an additional stock that purchased for an existing portfolio, under the assumption that the initial diversified market portfolio were held and optimally levered given the level of risk aversion and the additional stock was randomly selected. Accordingly, they noted that the application of DCA strategy is a reasonable prescription for an extra security investment added to a well-diversified portfolio. However, they found that the advantages of DCA over LS will be alleviated when the portfolio is initially optimally levered. Through the empirical evidences, Brennan et al. (2005) concluded that the performances of DCA strategies strongly hinge on the risk

aversion levels of investors, the superiority of which can be mitigated by the optimal levered portfolio given risk aversion.

Greenhut (2006) concentrated on the study of the primary advocated explanation of DCA that the investment strategy produced an average lower cost per share over the funds spreading period and lead to a larger number of stocks purchased compared with LS strategy. The purpose of the paper was clearly stated by the author to challenge and refute the popular numerical illustration. This research negated the superiority of DCA in the context of the behaviour of stock volatility by the first (customary) price pattern that had equal variations from its centre price or the second one that had equal percentage changes to its centre. Using Gordon model or constant growth model and considering the adjustment of interest rates, risk assessment, and potential economic growth change, he demonstrated that the illustrations were "*mathematical illusions*", which were solely "*based on arithmetic changes in a denominator leading disproportionate changes in the fraction*". In addition, he applied historical evidence to graphically examine his exposure of the invalidity of DCA's certain advantage. The data came from Yahoo! Finance was composed with monthly closing prices of 1,605 companies out of 2,000 random publicly traded corporations cross industries and style in the U.S. stock market. It was tested for a period of ten years from December 1995 to December 2004, which was divided into late 1990s with bullish stock market and early 2000s with bearish stock market. By means of the graph analysis, he claimed that investing in stock in the upward market does not favour DCA but purchasing stocks in downward market is advantageous for DCA, which lead to "*outcome from DCA is indistinguishable from that of LS when adjusted for the stock price trend*". However, Greenhut (2006) noted that in the sense of reward/risk trade-offs, DCA might be superior to LS due its risk reduction effect.

2.2.3 Literature of studies, showing DCA is superior to LS

The note of Wilson (1961) on accelerated dollar averaging was based on the William T. Morris' (1959) work on purchasing policy, which was to further extend his "*abbreviated treatment*", so as to "*fit more closely the nature of a dynamic programming problem".* In the paper, Wilson formulated a function for dollar averaging, assuming that a certain unites of shares are required in a finite time of investing

periods within a certain price range. He regarded dollar averaging as "*a type of the price prevailing at that time*" and also assumed the purchasing was operated until yielding lower costs per purchasing than "a policy of buying (total units/time periods) units per period. In this sense, he claimed that simple dollar averaging is optimal to the latter that a policy of purchasing a fixed amount of units, because "*it makes actual purchases in any period more sensitive to price*". Thus he had a supposition of accelerated dollar averaging policy that investors make the purchases in any period more sensitive to price than simple dollar averaging, which facilitate to lower the average cost of investment. As analyzed, he claimed that accelerated dollar averaging is superior to alternative simple dollar averaging and fixed units purchasing policy. Lastly, he proposed a puzzle about deciding the date on which the expected price can be minimal. According to the functions' results, Wilson noted that the research of accelerated dollar averaging "*fits more closely the nature of a dynamic programming problem*".

As stating that "*Dollar-cost averaging may not be rational behaviour, but it is perfectly normal behaviour*", Statman (1995) considered the issues of psychological advantages of DCA strategy from the perspectives of irrational investors through the comparison with Lump-sum (LS) investment strategy based on a number of previous researches of academics and practitioners. He constructed the investments into standard finance and behaviour finance two frameworks. The former framework is identified as "*a positive theory*", which consists to expected-utility theory and affected by the interactions between individual investors and financial markets. The latter one that associated with DCA strategy is the predominant issue to be investigated in this paper concerning the inconsistency between the application of DCA and the predictions of financial markets. His analysis was undertaken through four behavioural aspects: prospect theory, aversion to regret, cognitive errors and self-control (behavioural life cycle theory) from two separate viewpoints of standard investors and behavioural investors. Firstly, , they numerically illustrated the effectiveness of DCA based on the prospect theory developed by Markowitz (1952) and Kahneman and Tversky (1979) by means of standard utility function and prospect function. Accordingly, they claimed that the investing frames involved in DCA are important and advantageous over LS in the light of its impacts on investment decision-making, although they were identified as 'misleading' by Constantinides (1979). Secondly,

concerning the possibility to pride and regret the investing, he noted the ability of DCA to decrease the level of responsibility for investment. Lastly, due to the disagreement with Constantinides (1979) on the suboptimality of DCA which ignores the new information for investment, he argued the benefits of DCA that "*combat lapses in self-control as cognitive errors influence investors to terminate their investment plans*". Through all the analysis and arguments, Statman highlighted the consistence between DCA and behavioural finance and confirmed his persistence on DCA strategy, although he admitted its inferiority for a 'fully rational investor' in standard finance.

Israelsen (1999) attempted to confute the popular academic support on the out-performances of LS investing. His study was to illustrate the superior performances of DCA in terms of mean historical returns and standard deviation in contrast to that of LS strategy. In his paper, he argued the advantages of DCA by means of real numerical evidences, assuming that all taxes and loads were ignored and dividend and capital gain distributions were reinvested. The data analysed comprised 35 largest equity mutual funds from September 30, 1998 for ten years involving an enormous number of securities, which were sourced from Morningstar Principia Pro (October 1998). By historically comparing the ten-year performances between DCA strategy and LS investing, he found the evidences that 19 out of 35 largest mutual funds provided higher average annualized returns by DCA in contrary to LS. Moreover, in his samples, the superior performances of DCA were associated with lower standard deviation of return and larger dividend distributions compared with LS. Otherwise, he exemplified that funds with lower standard deviation, such as equity income or balanced funds generated higher average annual returns by employing DCA than those using LS investing. On the ground of the evidenced comparisons, Israelsen (1999) claimed that, as a result of "*funds with lower standard deviations of annual return many actually be better suited for DCA*", LS strategy "*doesn't always result in superior returns over DCA*", which is always linked to higher standard deviation of returns.

Khouja and Lamb (1999) initialled the study of DCA performances concerning the effects of transaction costs. On account of the properties of DCA investment strategy that composed by a number of small and regular investments and the commission for

each transaction might be charged by brokerage firms, they noted that "*a realistic case must include transaction costs because these costs can significantly affect performance and any related implications*". The purpose of the paper was to determine an optimal size of equity transaction and an optimal time interval between transactions to maximize the returns of DCA strategy. They assumed that investors using DCA strategy buy shares at regular and predictable intervals. In order to explore the optimal schedule, they created two transaction models: one with fixed costs and the other with variable costs. As analyzed, they claimed that with a fixed cost, "*the lower the transaction cost, the more frequently money should be invested in the equity market and the lower the capital buildup*" and with a variable cost, it "*encourages investors to buy larger amounts of equity per transaction*". In addition, Khouja and Lamb graphically analyzed the effects of transaction costs from the aspects of transaction cost on per transaction and annual basis, total expected annual return for different transaction cost sizes and total expected annual return function under separate assumptions. Moreover, they employed numerical examples in different situations and sensitivity and risk analysis to test the model results. Accordingly, they concluded that, considering both of fixed cost and variable cost structures, "*a simple dollar cost averaging strategy must include the impact of transaction costs, otherwise returns can not be maximized*".

Dubil (2005) examined the significant risk reduction of DCA investment strategy which automatically spreads the wealth over time by comparing with the LS policy which put chunks of funds up front. He was to explore the better long term asset allocation such as the underlying assets of stocks, bonds, mutual funds, or Certificates of Deposits (CDs). Concerning people may fail to meet their investing goals, he looked at not only the mean and standard deviation of returns, but also the shortfall probability and the conditional expected shortfall conditioning on the shortfall incurring. Firstly, Dubil discussed the return benchmarks for DCA from the perspective of one single stock that the only way to probabilistically view the issue is to estimate the expected return and volatility, as stock price predictions are inexecutable. He emphasized the psychological advantages of DCA policies, which avoid the behavioural biases of investors. His arguments were based on the study elaborated by Kahnemann and Tversky (1979) regarding the investors are irrational and loss averse and claimed that their investment performance benchmarks are unfixed. He preferred 'buy all up front'

strategies for low risk cases and favours DCA, "*rationally optimal strategies*" for high risk cases. In the views of his risk metrics, the absolute value for the standard deviation of terminal amount meant the relative certainty about the returns. The lower the ratio is, the more risk will be reduced; and verse vice. Secondly, on the observation of Asian options, Dubil illustrated the dampening effect of DCA on the volatility of option values applying the derived formulas and comparing the volatilities between the average and the underlying stock for various averaging periods and times to maturity. In his investigation, he compared DCA strategy with one-time-up-front strategy for both shorter and longer time horizons, different returns of stock and varied annual volatility scenarios by means of Monte Carlo Simulations. From the results, DCA works more effective in the risk reduction for riskier investments. Leveraged up-front strategy makes greater excess returns than DCA; however, it is not worth the extra risk. As he concluded, LS favours more for long-term investors to do low-risk investments and DCA delivers important advantages for underlying high-risk assets to have the risk reduced.

There are several literatures and financial companies supporting DCA, which is especially regarded as an effective, simple and straightforward strategy for long-term growth, for instance, retirement planning. DCA is popularly advised by a lot of practitioners as a retirement investment routine. Tachino and Woerheide (2005) considered DCA strategy as one of the accumulation strategies and advised investors to apply it together with Buy and Hold approach for equities investments. As one out of ten recommended retirement investment strategies, DCA was noted to be advantageous on "*not be swayed by attempts at market timing*". Also, referred to Flex-funds (2007), it was regarded as "*a better strategy to building wealth through regular contribution*" compared to LS annual contributions achieved at the wrong time, such as purchasing at higher prices than average. Due the uncertainty of the financial market, AnnuityAdvantage (2003) recommended DCA to retirees to manage retirement planning for a long-term proposition. As they stated, though not ensuring a positive return or risk-reduction guarantee, DCA provides automatic services regardless the fluctuation of stock prices. Additionally, SunLifeFinancial (2005) suggested that LS is more suitable for conservative investment in contrast to DCA, which is optimal for more aggressive investment, so as to protect the savings while allowing it to grow in both the rising and falling stock market.

2.3 Criticize the momentous views in field

Overall, DCA has been widely researched and debated over such a long period of time by academic researchers and financial practitioners. In this dissertation, chronologically, it covers the studies in field over forty years (from Wilson 1961 to Chen and Estes 2007). Apparently, it was impossible to include an entire review on the DCA literature. Therefore, it was decided to restrict this critical review to article published most related to the topic of investigation of DCA. Totally, 27 out of 40 papers were assigned to constitute the primary of this paper by analytical methods. Numerous researches have been undertaken in light of historical market performance, empirical models and theoretical discussion. "*The trouble is not with what the author does say, but with what he does not say.*" (Whitehead, 1967: 23)

As Nairn et al. (2006) noted that a good literature review goes well beyond a cursory acknowledgement of other authors working in the area, after listing a series of past studies in the form of description, more insightful literature reviews are to move towards a structured summarization and critical analysis of the research, so as to generate enlightened research thinking. There are three viewpoints of the articles: DCA is suboptimal to LS, DCA is optimal to LS and mixed opinions of DCA and LS. Having classified articles through their fundamental observations for granted, researches are undertaken to move forward on a corresponding view-by-view basis.

2.3.1 Literature of studies, showing LS is superior to DCA

In this section, eleven articles were identified as belonging to this category, including Constantinide 1979, Knight and Mandell 1993, Rozeff 1994, Thorley 1994, Bacon et al. 1997, Marshall 2000, Vora and Mcginnis 2000, Scherer and Ebertz 2003, Johnson, 2004, Williams and Bacon 2004 and Chen and Estes 2007. The research might be led on from here to appraise the literatures in the light of the advantages of LS strategy over DCA strategy, focusing on the aspects of expected returns and risk reductions, investment timing and flexibility and the fallacy of the favours to DCA.

2.3.1.1 Expected returns and risk reduction

From the results analysis of Knight and Mandell (1993), it was found that the higher the degree of risk aversion, the relatively lower returns produced by DCA, compared with the other strategies. In other words, the DCA favours riskless assets more. Their research provided logical and explicit arguments about the under-performance of DCA against the Optimal Rebalancing (OR) strategy and Buys and Holds (BH) strategy, which include graphical analysis, numerical simulation and empirical actual data test. Their study took into the consideration of investors with different degrees of risk aversion. But there are also some flaws in the paper. For one thing, they highlighted the suboptimality of DCA from returns and risk avoidance two aspects, but their discussions were only concentrated on the expected returns and averaging mean annualized return, leaving the standard deviation aside. For another, the favour of OR strategy was entirely on the basis of the assumption that investors know best asset allocation to optimize their utility, which was not reliable in the practical world.

Bacon, Williams and Ainina (1997) demonstrated that investing immediately provides the higher return than spreading investment through time and found that the less the number of the DCA instalments is, the higher the return it generates. They concentrated on the study of the under-performances of DCA in bonds market, rather than in the field of equities, which have been amply discussed. Their researches provide the groundwork to fill the gap in the literature bound with the bonds. However, the work is certain one-legged. For one thing, it only examines the performance of DCA from 1926 to 1995 for 70 years fairly long-term investment, without the considerations of the performances of relatively shorter term investing. For another, their analysis was based on the assumption that there is a large amount of endowment to invest, which to be invested by monthly using the portfolio of T-bills and corporate bonds. The situation of investment funds is available through time is not included. In addition, as a part of the conclusion, they claim that DCA is helpful in reducing the investors' undue fear, which need more demonstrations.

Claiming "*cost averaging is inefficient*", Scherer and Ebertz (2003) refuted the argument that cost averaging is advantageous in volatile market. They provide us mathematically theoretical arguments of cost averaging without the comparison with

other investment strategies. As one of the scholars that stating the suboptimality of cost averaging, they provided additional insights on the performance evaluation from the perspective of asset pricing theory. They refuted most of the popular studies on the measurement of cost averaging in terms of statistical risk measures and investors' utility functions, nevertheless, lacking the sufficient argumentation to convince their points of view. Moreover, the approach applied to prove and quantify inferiority of cost averaging is unapparent stated. Overall, their conclusions are based on rough arguments with insufficient statistical support.

According to the comparison, William and Bacon (1994) propose a finding about the relationship between the frequency of DCA investing and its returns, which is that the mean annualized returns of DCA is disproportional to the number of DCA instalments and the sooner to invest, the higher the realized return to gain. Facing the problem for financial players to select the better sizable investment strategy, their study statistically examines the effectiveness of various DCA strategies and LS investing policy by providing explicit analysis of them. For example, they compare three different DCA policies with LS through various length of investing period. However, the shortest period is 1970-91 for 22years. The results are merely based on a long period, which doesn't concern their performances in the view of 1-5 years, any shorter investing period. What's more, their result for one year monthly return comparison is on the basis of bull market in 1980s. Thus, it only means LS can outperform than DCA in upwards market, not concerning the downwards market.

Not involving the concerns on LS strategy, Chen and Estes (2007) claimed that DCA is more suitable for investors with a low annual target growth rate that less than 8 percent or a high annual rate that more than 12 percent. Concentrating on averaging investment strategies, they provided empirical performances comparisons on DCA and VA. Additionally, they noted the importance of terminal returns as an effective measurement, so did the concerns on risk/reward trade-offs comparisons. As they argued, from the perspective of investors in the framework of retirement plans, DCA is inferior to VA strategy.

2.3.1.2 Flexibility and Timing of investment

With the assumptions of perfect stock market, Constantinides (1976) criticizes DCA is dominated by both a sequential optimal and optimal nonsequential investing policy by use of the utility function model since DCA is incapable of adding new information of the market into decision-making. Demonstrating the inefficiency of DCA, his rigid arguments on the suboptimality of DCA investing policy are prevalent in the field of study and referenced by numerous academic scholars. He initially defines the natures of DCA as an investment policy related to the investment planning horizon and compared it to both of the constantly and inconstantly rebalanced investment policies. He made the further conclusion by taking one step ahead of Pye (1971)'s research on the optimality of gradual policies, which states the under relation of DCA to gradual policies and stresses not any gradual policies as suboptimal as DCA is.

Rozeff (1994) noted that "Invest without delay" – LS is superior to DCA policy. Otherwise, the investment spreading will suffer a performance penalty compared with the immediate risky asset investing. The study examines the performance of DA and LS across different investment periods, especially with the correct risk adjustment between the two investment policies. But the conclusion is just partial convinced, since as assumed, it only focuses on the increasing stock market but not considering for both of the downward and upward market tendencies. He mentioned the benefit of DCA to avoid investing all the dollars at an inappropriate time, however, he doesn't approve DCA is not superior to LS in this situation.

Johnson (1994) illustrated DCA as an alternative strategy to investing by timing the market is inferior to LS strategy and noted that the smaller the number of investment instalments is, the higher the return the investment strategy produces. He provides clear arguments about market timing by examining the impacts of missing the best and/or the worst investment days based on apparent historical evidence. In his research, there are explicit explanations of the data he applied. He What's more, he examine the performance of DCA involving not only the popular S&P 500 index but also NASDAQ Composite Index, DJ Composite Index and DJ Utility Index, in addition to which the research covers both the stock and bond market. However, as titled "market timing versus DCA", he doesn't discuss the two issues connected to each

other, although he concludes that timing the market doesn't work for the investment decision making and DCA as its alternative strategy yet is under-performance compared with LS strategy.

2.3.1.3 Fallacy of the favours to DCA and others

In the view of Thorley (1994), the whole underlying notion that it is a fallacy that DCA generates higher investment performance than LS is biased. Firstly, on the basis of historical evidence from 1926 to 1991 without considering the shorter investing periods, he asserts that "*DCA has no value*", which stands solely on the 66-year long-term observation and the assumption that no return for DCA's not invested funds. However, in reality, the waiting investment funds are always invested through Treasury bills to accumulate interests. Secondly, the final value of the investment is not only according to the current price of shares but also the total amount of shares owned. He just highlighted the historical role of average cost, ignoring the effect of lower average cost increasing the number of shares gained. Thus, his view is biased. In addition, in his conclusion, he claims that DCA policy cheats on wage earners and relatively disrupts their monthly saving plan. The assertion is subjective and unpersuadable. Nevertheless, based on his assumption, the author's research provides the empirical evidence of the slightly inferior performance of DCA, which also consider the situation of efficient and inefficient market.

Marshall (2000) note that investment technique yielding lower average cost than another is not significant as much as the expected return generated and associated risk avoided, which in contrary to Greenhut's (2006) study on DCA's lower cost numerical illusion. Without direct comparison between DCA and LS, provides numerical examination among Value Averaging (VA), Dollar-cost Averaging (DCA) and Random Investment (RI). Although DCA is testified as inferior to VA in terms of expected returns using IRRs, it is indistinctly indicated that "*no statistical difference between DCA and random investment techniques either in expected return or in risk avoidance*".

In practical, as a pinpoint of this paper, Vora and McGinnis (2000) noted the favour of DCA strategy for investors as retirees with limited amount of money for investment. However, all their results are strongly based on the assumption that DCA for stock investing is inferior, which seemingly made their converse utilization of DCA concept –"*dollar cost disinvesting*" logical. Not focusing on the performance measurements of DCA and LS investment strategies, they quantitatively and analytically researched the asset allocation decision-making in retirement plans.

2.3.2 Literature of studies, having a mixed opinion about DCA and LS

Ten articles were assigned to this level in the grounds that the authors explicitly set out to investigate DCA with mixed opinions, composing of Pye 1971, Sameulson 1994, Braselton et al. 1999, Abeyseker and rosenbloom 2000, Atra and Mann 2001, Leggio and Lien 2001, Leggio and Lien 2003, Bierman and Hass 2004, Brennann et al. 2005 and Greenhut 2006. The study are about to carry on appraisals in accordance with the dominated advantages of one strategy over the other, focusing on the points of expected returns and risks reducing, investment timing and flexibility and psychological considerations.

2.3.2.1 Expected returns and risk reduction

Under the assumption that the expected rate of return exceeds the risk-free rate, Abeysekera and Rosenbloom (2000) insist the viewpoint of DCA's suboptimality in terms of lower stock returns in the upside stock market; however, they stress the risk reduction effect of DCA in terms of lower standard deviation. Furthermore, they provide a further argument that comparison result between investment strategies is conditioned on investors' own perspective. They use a Monte Carlo simulation model as their main research methodology. They also discuss about the properties of simulation, which is flexible and easily modified to apply and can provide "*a more complete picture*" by a number of replications for the investments' outcomes. On the basis of the historical evidence, they consider the performance measurements of LS strategy and DCA strategy taking into the account of distributional properties.

As one of the proponents who acknowledge the suboptimality of DCA as an investment strategy, no surprise that Leggio and Lien (2001) remain LS as a superior investing strategy over DCA. In addition, the viewpoint that LS yields higher mean excess return is corresponding to that of Rozeff (1994), who claims the fallacy of DCA investing by use of the classic mean-variance approach of Markowitz's (1959). Except the lucid depictions of four investment choices: Dollar-Cost averaging (DCA), Lump-Sum (LS), Buy and Hold (BH) and Value averaging (VA), they provide explicit empirical test of them based on Statman's behavioural rationale and historical evidences. By comparing the expected utility function and the Prospect theory value function, they consider the investment measurements involving the aspect of investors' loss-aversion. From the perspective of data employed, they call into the tests covering both the underlying assets with higher and lower volatility. Moreover, they take into account the "*anomalous situations*", such as 'the January effect'.

Furthermore, since many studies have examine the performances of DCA investment strategy in terms of expected return and standard deviation, the scholars also conduct a range of performance measurements by means of risk-adjusted return, like the study of Leggio and Lien (2003) did. They pointed out that the popular Sharpe ratio generates reserve ranking results compared with the "more accurate" Sortino ratio and the upside potential ratio **(UPR)**. The Sharpe ratio ranking results show that DCA is the most preferred strategy for risk-free asset compared with LS and VA. However, using the Sortino ratio and upside potential ratio, they found that LS is superior to DCA for both corporate bonds and government bonds. From the perspective of data applied, they consider both the longer 74-year period and the shorter 30-year period and explore that there is no significant difference between the reported results. In addition, they amply analyze the annualized excess returns and risk measurers by two presumed portfolios concerning the diversification strategy.

Claiming that DCA is suboptimal under "*standard assumptions about capital markets*", Brennan et al. (2005) noted that the performances of DCA strategies strongly hinge on the risk aversion levels of investors. But it is noticeable that they provided an additional insight on the heuristic value of DCA and highlighted its benefit on the extra stock investment of a well-diversified portfolio. Distinct from the psychological considerations for irrational investing behaviours, they concentrate their research on

the practical manipulation of DCA strategies and the empirical evaluation of it in contrast with alternative investment approaches in term of market portfolios, ignoring the transaction costs and market information impacts. But their conclusion about the advantages disappearance of DCA is heavily resulted from the assumption of the initialled optimal market portfolio, which is difficult to achieve in the real world.

Dubil (2005) empirically illustrates the risk reduction advantage of DCA through computed statistics using formulas and further explicit Monte Carlo simulation to do the comparison between investing up-front and investing averaging. In order to support his arguments for the DCA, he employs the behaviour theory due to investors' psychological biases as many academics. He considers generous scenarios for both older people who may near retirement and younger investors with short or long time horizons, different returns of stock and varied annual volatility. However, his researches are only concentrated on long-term investment and neglects the most important investing purpose: maximising the expected utility.

2.3.2.2 Flexibility and Timing of investment

Though presumed that DCA has the advantage of risk reduction, Braselton et al. (1999) regarded the property of DCA that requires investors spreading investment funds periodically as a disadvantage of inflexibility. What's more, they claimed that "if the funds are available, LS can produce substantially higher returns than DCA with available funds. Dissimilar from the most of the researches on DCA and LS investment strategies providing purely or mixed theoretical arguments or numerical comparisons based on simple calculations, they evaluated the strategy performances greatly based on mathematical and computational calculations and techniques from the perspective of the random walk of stock prices, without the considerations of transaction costs and taxes and psychological advantages. Overall, their study simply included few specific assumptions that an investor has an initial investment funds and interest rates accumulated during the investing periods, however, especially excluded the supposition of stock market to be upward or downward, which offering an unlimited measurement results.

Atra and Mann (2006) examine the strategies in the concept of seasonality and detailed analyze their performances over different investing period to explore the best timing to begin the certain strategy. Particularly, they consider not only the benchmark U.S. stock market indices but also the popular indices across international areas. They compare the LS and DCA strategy by use of a self-financing portfolio, in order to ensure the comparison between strategies is on the equal footing, regarding to their different timing of invested cashflows. They provide the similar results with Rozeff (1994) about DCA's inferior risk reduction performance. However, their arguments are solely based on the 'current month mean return', rather than the comparison between the terminal values of investment strategies.

2.3.2.3 Psychological considerations

Although disagree with the ability of dollar averaging to maximize the expected utility, Pye (1971) agreed the advantage of dollar averaging in terms of psychological considerations, such as the effect of a regret criterion, rather than the out-performances for expected returns or terminal values achieved. He provided the study of dollar averaging in the roles of minimax policy and nonsequential policy for investors. He employed theoretical arguments and mathematical formulations to explore the performances of dollar averaging numerical illustration or evaluation, by comparing with sequential policies. Most important of all, his study of the suboptimality of DCA as one of the gradual policies contributed to the influential arguments of Constantinides (1976) on the suboptimality of DCA strategy.

Bierman and Hass (2004) stressed Statman's contribution on the study of DCA's behaviour considerations but suspect the advantage of DCA on avoiding psychological investing problems, whose researches focus on the critical discussion of previous academic studies including both publishes journals and professional books. In the analysis, the classification of the generated investing funds: 'currently available' and 'additional through time' is explicitly proposed. However, the empirical evaluations are insufficient to prove their viewpoints, most of which are strongly based on certain assumptions. Furthermore, their arguments are on the basis of assuming

the value of expected return toward cost of equity, which is not down-to-earth that the future prices are not predictable in the real world.

As discussed, a number of academic authors and practitioners have theoretically and empirically researched the performance of DCA in comparison with LS. But most of them focus on the examination of the strategies in terms of expected returns and standard deviation and acquiesce in the rationality of the fundamental explanation of DCA's benefits. Considering the behaviour of stock volatility, Greenhut (2006) provides additional insight for the investigation of DCA from the perspective of mathematical exposure. However, they made their conclusion that DCA strategy performs equitable to LS strategy simply in the sense of averaging stock prices, regardless of other aspects, such as the possible psychological advantages.

2.3.3 Literature of studies, showing DCA is superior to LS

Six articles were assigned to this category, involving Wilson 1961, Statman 1995, Israelsen 1999, Khouja and Lamb 1999, Milevsky and Posner 2003 and Dubil 2005. The research kept an eye on evaluating the literatures with a concentration of the benefits from DCA strategy opposed to LS into dimensions of increased returns and reduced risks, flexibility of investment and psychological considerations.

2.3.3.1 Returns and Risks

As a proponent of DCA strategy, Israelsen (1999) noted that DCA strategy is advantageous for less volatile investment by providing numerical examinations of the performances of DCA compared to LS investing on the basis of historical evidences. However, as the returns of LS investing were identical using the data of equity mutual funds on September 30 1998, his results are confined and not general for an overall investing situation.

As "*many conventional models ignore transaction costs*", Khouja and Lamb (1999) provide us the additional significant insights into the impacts of transaction costs on DCA investment strategies for investors. What's more, they create models for both

fixed and variable transaction cost structures to investigate the optimal transaction size and the optimal time interval between investments, so as to maximize the returns of DCA strategy. However, their research only concentrated on the study of DCA regardless the research of the other strategies, for example, LS. Thus, their results just offer the conditions of transaction cost to generate an optimal DCA compared to itself without the comparison to alternatives.

Milevsky and Posner (2001) start they study slightly differently from most of the authors, who have shunned the advantages of DCA strategy and reiterate its irrationality opposed to LS strategy. Although maintaining the irrationality and mean-variance inefficiency of DCA, they examine that there is certain level of volatility that DCA makes higher expected conditional payoff than LS, conditioning on the pre-determined final value of the underlying security. Moreover, they stress the consistency between the conditional fixed value and the behavioural expectation of individual investors, as a complement to the behavioural theory of Statman (1995). However, their conclusions are strongly based on the assumption that the investors have clear target returns or are able to predetermine the final value of the investment instruments with high volatility, which are considerably uncertain and unreliable in the real world. Thus the fundamental of the conjecture is practically unstable.

2.3.3.2 Flexibility and simplicity of investment

The paper of Wilson (1961) noted that the dollar averaging which is more sensitive to prices is optimal to a fixed units purchasing policy. However, he provides us a simplified discussion about dollar averaging, focusing on the analysis of accelerated dollar averaging based on the acknowledgement of simple dollar averaging. It is a purely theoretical research composed by functions and mathematical analysis without numerical examples, illustrations or comparisons with alternative investing approaches.

2.3.3.3 Psychological considerations

Based on the study on prospect theory of Markowitz (1952) and Kahneman and Tversky (1979), Statman (1995) provided further development and predominant exploration on the behavioural finance consistent with DCA in contrast with standard finance. Rather than evaluating the performances of DCA in terms of expected return or standard deviation, he undertook theoretical and explicit arguments on the advantages of DCA simply from the perspective of psychological considerations of individual investors. However, he persisted in the suboptimality of DCA strategy under the assumption of "*fully rational investors*". On the contrary, Samuelson (1994) claimed that "*sleeping well for irrational reasons, is as good as sleeping well for rational reasons*", diminished the advantage of DCA over LS investing strategy as **Statman (1995)** argued.

2.3.3.4 Summary of Criticism

In summary, the opinions on the performances of DCA investment strategy are highly controversial between the academics for a long period. There are eleven papers that preferring LS to DCA, six articles supporting the optimality of DCA to LS and 10 scholars providing mixed opinions on the performances of DCA. Of the limited papers that reviewed in this dissertation, the number of proponents for LS almost doubles that of DCA. (See Figure 2.6 – Appendix 1) Thus from this perspective, the minority of researchers are favourable to DCA compared with LS, in contrast with the popularity of DCA among professional finance advisors. Nevertheless, it is important to highlight the fallacy on the cost advantage of DCA concerning their performances measurements, referred to Greenhut (2006), Wilson (1961) and Marshall (2000). As Marshall (2000, 91) noted that "*what really matters is the investment return achieved and the associated risk when a large number of comparisons are made*"**,** the lower average cost is not enough to make sure that one strategy is optimal performance than the others. With regard to the performances of DCA in terms of returns, the majority of researchers demonstrated that DCA generates lower returns than LS (See

Figure 2.7 – Appendix 1). Especially, Bacon et al. (1997) Johnson (2004) and William and Bacon (2004) noted that the less the number of the DCA instalments is, the higher the return it generates to clarify the inferiority of DCA in returns. In addition, regarding its performances in terms of risks, more papers observed the optimality of DCA in risk reduction, which is twice than that of LS (See Figure 2.8 – Appendix 1). With reference to the market conditions for DCA, there are also opposite views, for example, Rozeff (1994) claimed the upward market works better for DCA, on the contrary, Brennan et al. (2005) favour bear market for DCA. From the perspective of the volatility in the financial market, the disputes are fierce among scholars. Dubil (2005) demonstrated that DCA works better with higher risky assets. Opposite to that, Scherer and Ebertz (2003) claimed that cost averaging is less valuable in the volatile market with frequent prices up and down fluctuations supporting the view points of Leggio and Lien (2001) and Leggio and Lien (2003).

Chapter Three Research Methodology

The methodology intended to use in this dissertation mainly focused an intensive survey through the academic journals regarding this specific topic of investigation of DCA investment strategy. It is an important task due to the long-lasting controversy on the usefulness of DCA as an investment strategy compared with LS. The survey will blend the description of opinions, propositions or findings from the previous researches, the more insightful conceptual discussion and criticism on the literatures and the holistic graphical overview with numerical analysis. Furthermore, regarding to the summarized results of the literature reviews, the methodology of Monte Carlo simulation will be applied to test and verify DCA policy and LS investing numerically, so as to identify which one has the better performance in the light of higher returns, lower risks and in addition higher risk/reward trade-off ratios.

3.1 Data – Types and sources

The secondary data in regard to literatures of DCA will be accessed mainly from online journals and databases through Nottingham University Library and Information Service with the assistant of a selection of tertiary information sources for instance the library OPAC, commercial bibliographic databases and Internet search engines and directories. Sources accessed and retrieved have been critically organized and analyzed under the section of literature review.

As the Figure 2.9 – Appendix 1 shown about the data applied in the reviewed papers, Standard and Poor 500 Index has been frequently employed throughout all kinds of researches, which accounts for 37% of all and the frequency is even more than all the other dataset used. To set the database for the performance measurement between the DCA and LS strategies, we suppose the equity investment is a mutual fund that tract the index of S&P 500 and sells initially for £100 a unit, similar to those used in Abeysekera and Rosenbollm (2000) and Marshall (2000). Additionally, apart from testing DCA on the most popular S&P 500 index, two of the most popular UK Indices

are taken (Table 3.1): FTSE 100 Index and FTSE All Share Index, which have constituted the dividend paid by the companies in the index.

Table 3.1 Indices as Dataset Applied

Indices	Time Horizon
S&P 500 Index	3rd Jan 1950 - 1st Dec 2006
FTSE 100 Index	2nd Jan 1985 - 1st Dec 2006
FTSE All-Share Index	4th Jan 2000 - 1st Dec 2006

In order to attain more reliable results for simulation, we apply the close index prices as a basis sourced from the website of YAHOO - FINANCE, the same as Greenhut (2006) did. We employ the sample standard deviations of the monthly returns of the S&P 500 Index between 3rd January 1950 and 1st December 2006, FTSE 100 Index between 2nd January 1985 and 1st December 2006 and FTSE All Share Index between 4th January 2000 and 1st December 2006 as estimates of the standard deviation of the annual return. Seen from the Table 3.2 (Appendix 2), they results in annual standard deviations of 14.20% (S&P 500), 16.04% (FTSE 100) and 13.92% (FTSE All) and average annual returns on the stock of 7.77% (S&P 500), 7.21% (FTSE 100) and 1.15% (FTSE All) for the assumptions in the simulation. Typically, μ can be estimated either using historical data or using subjective estimate based on the current prospects for equities. (Abeysekera and Rosenbollm, 2000) Here, we use the historical data of real world, the same as the standard deviation of returns, to ensure the reliability of the results.

3.2 Methodology

In order to investigate the performances of DCA by comprising to LS investment strategy, both qualitative and quantitative techniques have been employed. Qualitative method has been amply performed through the use of intensive literature reviews, which facilitate to understand the DCA topic and sum up various views of a number of previous researches. Its general conclusion is helpful to set the presupposition for the following empirical test to verify the observed theoretical results. According to the comparison of methodologies applied in the researches (Table 3.3 - Appendix 2), simulation is the most popular empirical method employed by the

academics, accounting for nearly one third of all. We suppose that the simulation model could be a beneficial technique in measuring the performances between the DCA and LS strategies. Therefore, a quantitative performance test of DCA and LS strategies is conducted to undertake by use of the methodology of Monte Carlo simulation, including the comparison of expected returns, standard deviation of expected returns and simple risk-adjusted return ratios. The methodology will be employed under the random walk stock price hypotheses. A thousand simulations of investment results over time are used to calculate the data of first approximation for both of the DCA and LS investment techniques with the time horizon of 12 months. Finally, compare the results of mean return and standard deviation separately and the ratio of mean return/standard deviation to testify the literature results.

3.2.1 Monte Carlo simulation

Chance (2004) noted that Monte Carlo simulation is regarded as a legitimate and popularly used technique for dealing with uncertainty in many aspects of business operations. Monte Carlo simulation, a widely used class of computational algorithms, refers to an analytical method which imitates the behaviour of stock prices, interest rates and exchange rates in real-life. Especially for too complex mathematical problems, it randomly and repeatedly generates values to simulate a model and provide a numerical solution, which provides a summary of results with regard to a quantitative estimate of the range and distribution of the possible returns. (Decisioneering, 2005) The simulation can use random numbers from pools constructed with respect to the behaviour of stock prices. As Davenport (1992) claimed that, truly random numbers are not necessary for the method application, it is popular and easy to test and re-run simulations by means of deterministic, pseudo-random variables.

In this paper, simulation is used to calculate multiple scenarios of a DCA and LS investment model by sampling the values of stock prices over and over again from the probability distributions for the uncertain variables of the expected annual return on the stock and standard deviation of the annual return on the stock. In order to apply it, we need the equations that represent the probability distribution, which can define the

uncertain variables. A gBm process is incorporated into the simulation as a way of identifying the nature of stock price. The simulation for performance test of DCA consists of 1000 lognormal paths of stock prices that calculated by the spreadsheet[9] (Table 4.7 - Appendix 4). The DCA strategy consists of a gradual periodical investment in equal instalments totalling equal to LS, which comprises a one-time upfront investment. Outcomes regarding to DCA investment strategy associated with these random stock prices are analyzed to determine the likely quantitative results corresponding to the critical summation. For explicitly, we present monthly results by spreadsheet and compare the terminal values of DCA and LS.

3.2.2 Advantages of simulation

Curwin and Slater (2002) claimed that, a simulation model attempts to imitate the reality of financial system through experimentation rather than derivation. Stimulating an economic or financial activity allows the introduction of risk or uncertainty into the decision system. (Gentry, 1974) One of the significant contributions to the performance test is the application of a stochastic process to stimulate a range of possible outcomes for each variable rather than coming to a conclusion considering only a single factor. Additionally, Abeysekera and Rosenbloom (2000) stressed the study can also benefit from the simulation model by its flexibility and ease of modification, under various assumptions, such considering or ignoring the existence of transaction costs and dividend earnings. Monte Carlo simulations are favourable to guide a user to the best choice, based on personal requirements and purposes.

[9] Calculated by Risk Analysis add-on Software for Excel by Solver.com

3.3 Performances measures for evaluation

Firstly, in order to compare their performances in terms of cash flows, we use terminal values of DCA and LS investment strategies over the time horizon, which refers to the value of an investment at the end of a period, taking the account of the rate of interest.

$$T_V = P_V \times (1+r)^t$$

T_V = Terminal value of shares

P_V =Present value of share

r =Rate of interest

t =Period of time

Additionally, as noted by Hull (2006:305)**,** the lognormal property of stock prices can be used to provide information on the probability distribution of the continuously compounded rate of return earned on a stock between time 0 and T. The monthly rate of return is calculated by using of the current index price and the previous index price.

$$x = \frac{1}{T} \ln \frac{S_T}{S_0}$$

x = Annually continuously compounded rate of return realized between times 0 and T.

S_T = price of the stock at time T,

S_0 = price of stock at time 0.

Furthermore, Hatton (2005:28) noted that standard deviation mathematically measures the range of possible outcomes which represents the risk or uncertainty of the security or asset class of securities. Standard deviation measures the dispersion of the differences between monthly returns and its total average return over time, which is used to calculate the risk of index investment by DCA and LS strategies.

$$\sigma = \sqrt{\left[\frac{\sum (S - \bar{S})^2}{n}\right]} = \sqrt{V} = \sqrt{\sigma^2}$$

Where

σ =Standard deviation of expected returns

V =Variance

S =current return of a time horizon

$\overline{S}$ =average of returns over a given period

n =units of periods

What's more, reward/risk ratio has been opted to provide more accurate performance measurement of the investment strategy, by using a mean-variance criterion. An investor's reward to volatility trade-off demonstrates broader evaluation involving both return and risk. In this paper, it is simply to use the ratio between expected return over the sample period and the standard deviation of returns, since not paying much attention to the examinations of various risk-adjusted ratios.

$$\text{Reward/Risk ratio} = \frac{\mu}{\sigma}$$

Where

μ = continuously compounded annual return on the stock

σ = standard deviation of the annual return on the stock

3.4 Graphical analysis

In addition to the numerical measurements of DCA and LS strategies, graphical analysis were incorporated into the examination to portray a general observation of their performance for both of the theoretical arguments and scientifically evaluation, such as the proportion of the views supporting the optimality of DCA and a overall comparison between the rates of return achieved by the simulation approach. In this paper, as the most common graph formats, pie charts and histograms were applied to represent the values of a series of variables, which assist to divide the underlying dataset into categories, so as to achieve the resulting outcomes with differentiated patterns.

3.5 Hypotheses and assumptions

To avoid unnecessary complications and put the attention on the debated primary opinions on DCA in terms of returns and risks, we assume that the transaction costs,

taxes and dividends are ignored and the issues with respect to behavioural finance are avoided. (Consideration of dividend of all the companies constituted under FTSE All Share and FTSE 100 would be very tedious and lead to inaccuracy. Most previous researchers, who have used indices to calculate returns, ignore dividends.) But the model can be easily modified since factors can be incorporated into thereafter. We set the risk-free rate to zero, thus the expected return per period represents the excess return of stocks over the risk-free rate. We assume a scenario that investor P has £24,000 that prepared to invest upfront immediately into equities and investor Q using DCA strategy is currently available to invest one instalment of £2,000 over the given investing period. Hence, the presumption makes the performance evaluation simpler, by considering the rate of risk-free equal to zero. To stimulate the LS and DCA strategy, we follow the model of the stock price movement given by Hull (2006:434). Same as they did, we sample a random path with a lognormal distribution to model the price of a stock at time t.

$$S_t \sim S_0 \exp([\mu - \frac{1}{2}\sigma^2]t + \sigma\sqrt{t}N_{0,1}$$

Where

S_t = price of the stock at time t,

S_0 = price of stock at time 0 =£100,

t = units of years=1/12 (monthly)

μ = continuously compounded annual return on the stock,

σ = standard deviation of the annual return on the stock,

$N_{0,1}$ = random sample from a normal distribution with mean 0 and standard deviation 1

In the spreadsheet simulation model, we assume that the parameters of the lognormal distribution, μ and σ, be treated as constants. Based on the dataset of S&P 500 for a period from 3rd January 1950 and 1st December 2006, we estimated the annual standard deviation σ=14.20% and an annual return on the stock μ=7.77% as assumptions in the simulation.

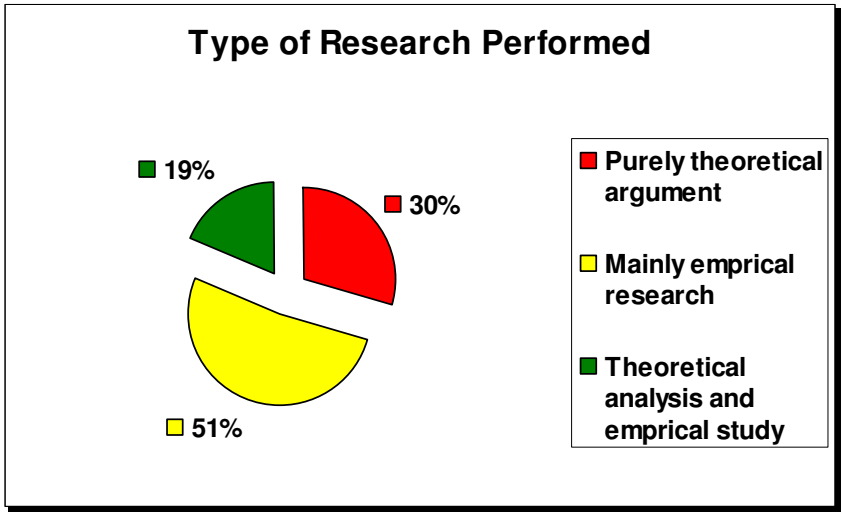
Chapter Four Findings and analysis

4.1 Graphical analysis for intensive survey

A literature review can have numerous different focuses, goals, perspectives, coverage strategies, organizations and audiences, which can be classified into the integrative research and the theoretical review. (Cooper, 1988) A thorough insightful investigation assigns reviews to the following three levels. Initially, cataloguing the carried out theoretical and empirical work in the field allows the researchers to identify gaps that they can contribute to knowledge. Summarization and criticism of their viewpoints provide a comprehensive understanding and a more investigative study, so as to approach an overview of the topic. Then identifying the current views on methodology in the area allows a more focus on the choice of techniques, assumptions and dataset underpinned which may direct the researcher's own further research questions, hypotheses generated and chosen area of study.

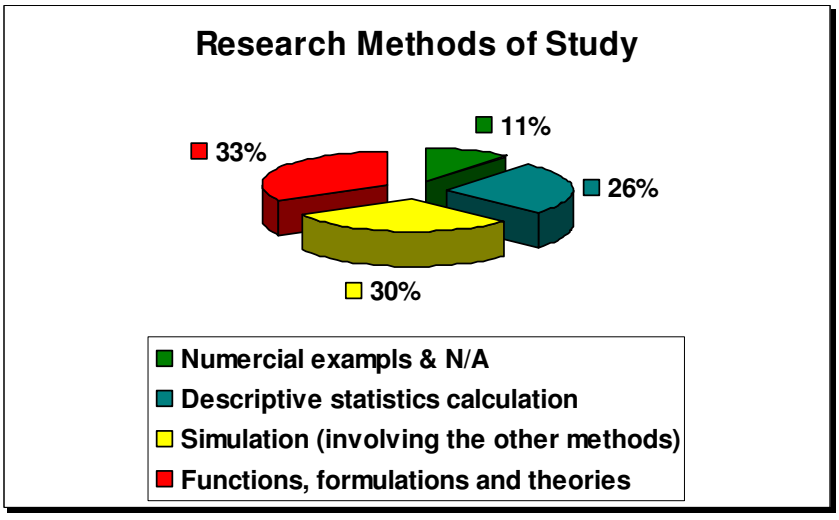
Most important of all, perusal of the literature provided an integrated look into the area of DCA with adequate and critical discussion and summarization. Confronting with papers ranging from mathematical models to theoretical studies to empirical illustration, various viewpoints of the literature in the context of DCA have been enumerated by table classification. (See Table 4.1 - 4.6 – Appendix 3) Moreover, the analysis should go deep into the factors resulting in the controversial opinions on DCA and LS investment strategies, in terms of types of research performed, research methods of study, assumptions on transaction costs and taxes, time horizon concerned, underlying assets invested and the psychological factor for DCA illustrated as follows.

Figure 4.1



Firstly, among the papers, seen from Figure 4.1, more than half the researches have performed the study by means of the purely theoretical argument and the researches on basis of mainly empirical methods accounted for comparatively less. Thus, in the field, more researches are required to focus on the quantitative evaluation and examination to provide more numerical tests and verification for the existing theories and analysis in practise.

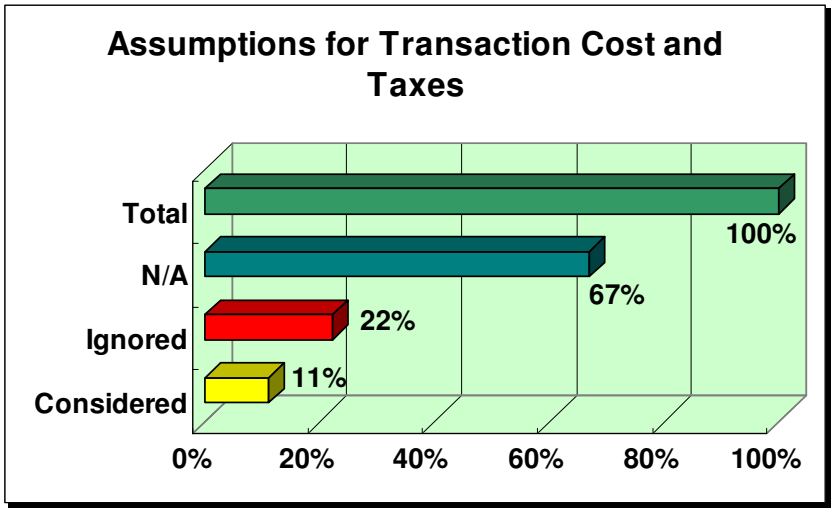
Figure 4.2



Secondly, as Figure 4.2 showing that the theoretical arguments and analysis with empirical study account for 70% papers of all, from the perspective of research methods of study, most of the researchers used functions, formulations, models and

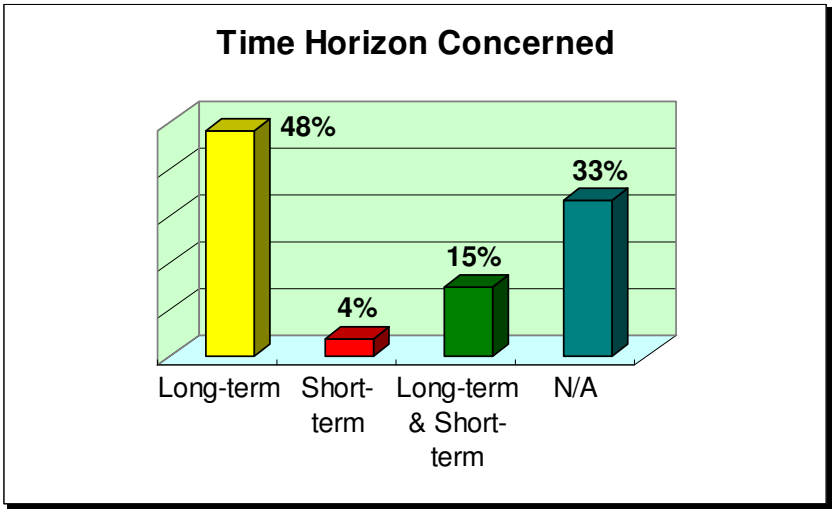
theories as the principal methods. Besides, Monte Carlo simulation was the most popular empirical method employed by the academics. The method of descriptive statistics, such as mean and standard deviation are more commonly used to represent the risks and returns than simple presumed numerical examples.

Figure 4.3



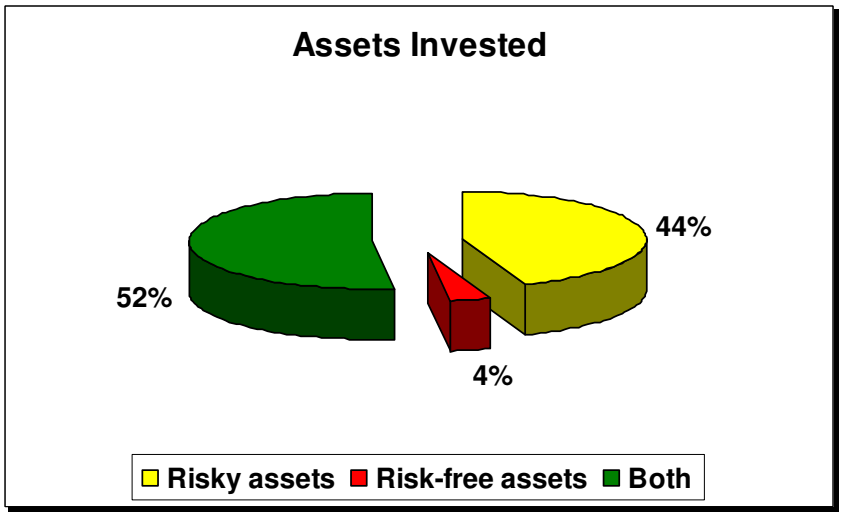
Thirdly, throughout the articles, there are debatable performance results of DCA strategy, attributing to various presumption proposed by the researchers. For one thing, the assumptions of transaction costs and taxes for numerical evaluations were diversified (Figure 4.3). Some of researches took into the account of the effect of the loads and taxes, such as Knight and Mandell (1993), Vora and McGinnis (2000) and Khouja and Lamb (1999). On the contrary, Constantinides (1976), Israelsen (1999), Marshall (2000), William and Bacon (2004), Brennan et al. (2005) and Atra and Mann (2006) generated their results by ignoring them. Most important of all, out of 27 researches, only Khouja and Lamb (1999) provided a focus on this topic and two thirds of them neglected their impacts on final results at all, although they play important roles in real life. Thus, more researches are required to involve these two factors.

Figure 4.4



For another, from the perspective of time horizon concerned, except one third of papers didn't pay any attention to this component, nearly half of the study concentrated on the long-term investment and a few papers examined the short-term performances as an addition to long-term one (Figure 4.4). There is only one out of 27 articles took an intense focus on researches for a short period. Although a number of professional advisors recommended DCA as an advantageous strategy for long-term investing, a deficiency of short-period research is apparent.

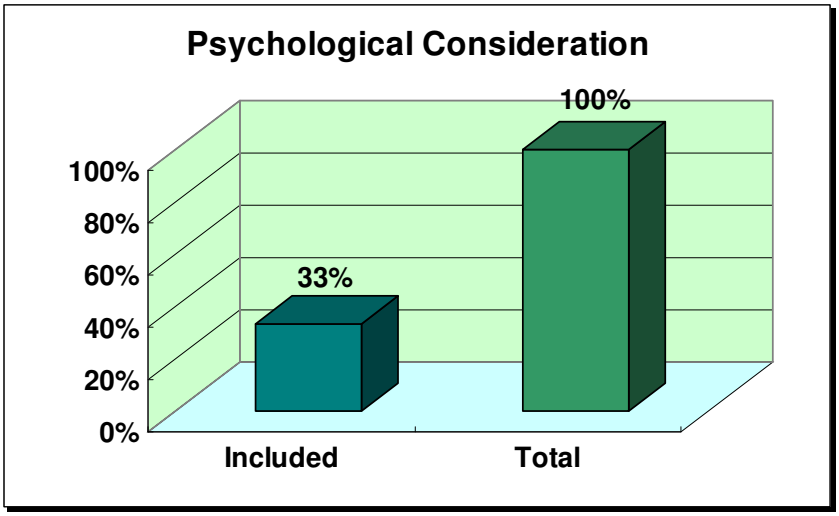
Figure 4.5



What's more, with reference to the underlying assets invested, most of the articles placed importance on risky assets, such as stocks, mutual funds and indices or

presumed that keep the remained investment funds of DCA strategy in Treasury bills to accumulate interest rates (Figure 4.5). Only Bacon et al. (1997) made the significant contribution on adding performances examination in terms of bonds. Obviously, the studies in field lack the concentrations on the underlying risk-free assets.

Figure 4.6



In addition, regarding the discussions on the benefits of DCA, there are 33% of academics involving the ppsychological consideration from the perspective of behavioural finance (Constantinides 1976, Bacon et al. 1997, Pye 1971, Samuelson 1994, Statman 1995, Leggio and Lien 2001, Milevsky and Posner 2001, Bierman and Hass (2004); Dubil 2005). 8 out of 9 researchers agreed with the advantages of DCA over LS in terms of regrets avoidance and self-control for investing for irrational investors and only Samuelson (1994) claimed that there is an equal chance for individual investors to regret or not and was disagree with the psychological benefits of DCA. Thus the behavioral factor is an essential feature of DCA, which should be considered.

4.2 Quantitative assessment of DCA and LS as investment strategies

In this section, the simulation test results regarding to the performances of DCA and LS investment strategies will be discussed by use of graphs and analysed with the link to the literature review outcomes. According to the proxy characteristic of the applied database – indices, the assessment will be undertaken from overall performances and consideration of volatility two perspectives.

4.2.1 Graphically analysis of comparison results

Exemplified as **Table 4.8** – **Appendix 4**, the spreadsheet models of DCA and LS strategies were repeated for 1,000 times. The simulation approach provides an estimate of the distribution of the terminal values for the two strategies with a 12-month time horizon. The simulation results on the basis of S&P 500 Index, FTSE 100 Index and FTSE All-share Index will be analyzed separately and collectively.

4.2.1.1 Under separate indices – Overall performances

Figure 4.7 give the distributions of the simulation results for DCA and LS strategies based on S&P 500 Index, which work the same as Figure 4.8 and Figure 4.9 for both strategies on the basis of FTSE 100 Index and FTSE ALL Index. The performance frequency graphs assist us to attain an overview of the outcome comparisons between DCA and LS strategies. In light of the data of S&P 500, DCA will produce lower rate of return but more risk reduction opposed to LS strategy. By use of the FTSE 100 Index and FTSE All-share Index, the simulations both provide approximate results to S&P 500. Therefore, the rough observations support the benefit of LS strategy in generating higher returns and the advantage of DCA strategy in avoiding risks in contrast to each other.

Figure 4.7 S&P 500 Index – Distribution for Rate of Return of DCA strategy and LS strategy

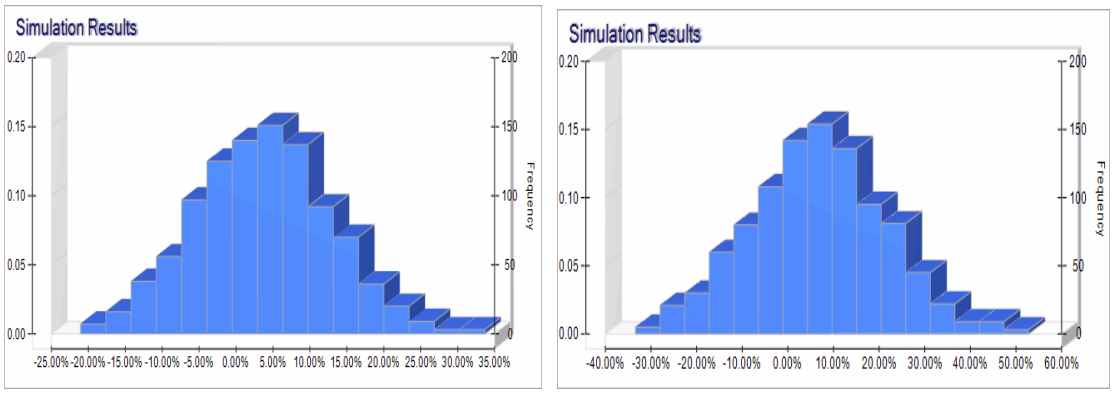


Figure 4.8 FTSE 100 – Distribution for Rate of Return of DCA strategy and LS strategy

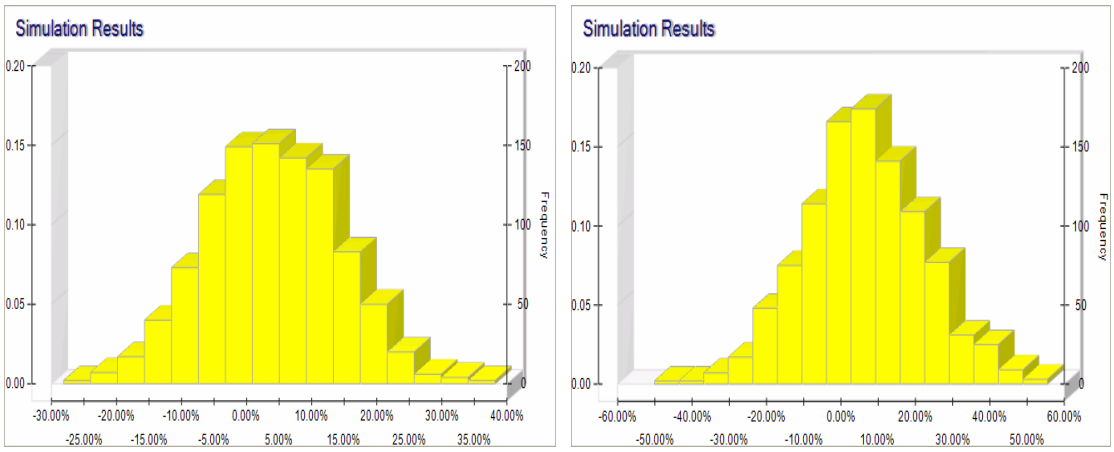
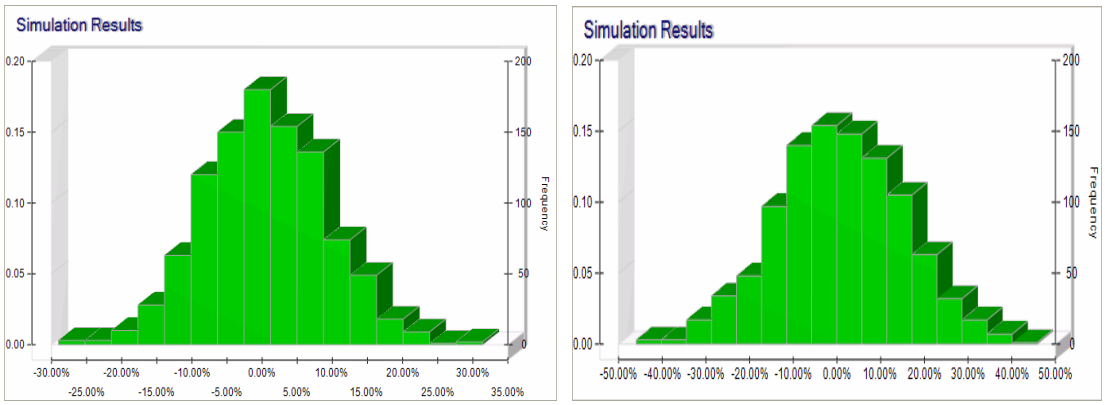


Figure 4.9 FTSE All-share – Distribution for Rate of Return of DCA strategy and LS strategy



4.2.1.2 Combine three indices – Volatility consideration

As shown in the foregoing Figure 4.7 - 4.9, vertical comparison among the strategy performances will facilitate the analysis to achieve an overall outcome, by associating the three indices' results with each other. For one thing, both the DCA and LS strategies work better with S&P 500 Index and FTSE 100 Index in contrast to FTSE All-Share Index, which generate not only lower risks but also higher rate of return. For

another, with reference to the simulation results of FTSE All-Share Index, both of the strategies result in lower rate of return but without the reduction of risks. According to the proxy characteristic of the applied database – indices, Thus, according the simulation results, DCA strategy is more favourable for lower volatility assets, so does LS strategy do.

4.2.2 Numerically analysis of comparison results

Table 4.7 **(Appendix 4)** presents the simulation model samples of DCA and LS strategies of S&P 500 Index, FTSE 100 Index and FTSE All-share Index respectively, which are calculated by using of Excel Risk Solver add-on software. The quantitative results of simulation will verify the graphical view by comparing in terms of expected returns, risks and risk-adjusted returns.

4.2.2.1 Results in terms of returns and risks

Table 4.9 Summary Statistics for Simulation Experiment - S&P 500

Statistic	DCA	LS
Rate of return	8.53%	**15.65%**
Expected annual return	3.73%	**6.73%**
Standard deviation of expected return	**8.50%**	13.72%
Mean of Terminal value (£)	250,034	**259,131**
Standard deviation of Terminal value (£)	**21,367**	35,526
Maximum	355,640	390,616
Minimum	190,337	160,269

Table 4.9 presents the summary statistics of S&P 500 Index from 1,000 times simulation. With respect to the expected annual return and mean of terminal value, LS strategy outperforms than DCA strategy. Based on the standard deviation of expected return, LS is inferior to DCA.

Table 4.10 Summary Statistics for Simulation Experiment - FTSE 100

Statistic	DCA	LS
Rate of return	2.99%	**9.75%**
Expected return	3.39%	**6.05%**
Standard deviation of expected return	**10.26%**	16.16%
Mean of Terminal value (£)	**26,765**	25,631
Standard deviation of Terminal value (£)	**2,284**	4,009
Maximum	35,230	43,952
Minimum	20,902	14,944

These outputs of **Table 4.10** are achieved by the simulation using data of FTSE 100. Similar to the results of S&P 500, DCA strategy is optimal than LS strategy regarding to the standard deviation of expected return and it is underperformed concerning the expected return. But it provides better outcomes of mean of terminal value than LS.

Table 4.11 Summary Statistics for Simulation Experiment - FTSE All

Statistic	DCA	LS
Rate of return	8.12%	**14.96%**
Expected return	**-0.09%**	-0.65%
Standard deviation of expected return	**8.71%**	14.00%
Mean of Terminal value (£)	**26,088**	24,097
Standard deviation of Terminal value (£)	**1,821**	3,208
Maximum	32,323	38,010
Minimum	20,915	15,506

Table 4.11 summarizes the simulation results of FTSE All-Share Index, which shows that DCA beats LS strategy in terms of both higher expected return and lower risk. As FTSE All with higher volatility in the financial market, the outcomes indicate that DCA is more favourable to invest in more risky assets in contrast with LS strategy.

4.2.2.2 Results in terms of Risk/reward trade-off ratios

Table 4.12 Summarized Risk/reward Trade-off performances

Reward/Risk Ratio	DCA	LS
S&P 500 Index	43.91%	**49.08%**
FTSE 100 Index	33.07%	**37.43%**
FTSE All-Share Index	**-1.07%**	-4.65%

To evaluate the performance level with each strategy, the simple risk measurement and return measurement are not sufficient. To compare the strategies, a metric of reward/risk trade-off and indices will be used. Seen from the Table 4.12, LS has better reward/risk trade-off for S&P 500 and FTSE 100 by comparing with DCA strategy, which represent larger reward for risk-bearing. Not surprisingly, the better trade-off of FTSE All-Share achieved by DCA, again, demonstrates the superiority of DCA over LS for the more risky assets.

4.3 Summary of the empirical results

Table 4.13 Summary of Performances Comparison

Better performance strategy	S&P 500	FTSE 100	FTSE All-Share
Expected annual return	LS	**LS**	**DCA**
Standard deviation of expected return	**DCA**	DCA	**DCA**
Risk/reward trade-off	**LS**	**LS**	**DCA**

To sum up, in light of the summarized statistics achieved by Monte Carlo simulation (Figure 4.13), investors can benefit from DCA for reducing the investment risks and can take the advantage of LS to increase the total returns. Therefore, it is incautious to assert and identify an absolutely superior investment strategy between DCA and LS strategies. But the results regarding the returns contradict to the claims of them, and Israelsen (1999), Miles and Posner (2001) and Atra and Mann (2006). Furthermore, similar to LS strategy, DCA is more favourable for lower volatility assets by comparing

with alternative DCA strategies themselves. However, in contrast to LS strategy, DCA provides outperformances for higher volatility investment due its instinct ability to decrease risks by spreading the money over the given period. These results appear to be reasonable in accordance with the research outcomes of Dubil (2005) and Scherer and Ebertz (2003). In short, consisting with the belated views of Brennan et al. (2005), the decision-making on the performance measurements is greatly dependent on the risk aversion levels of investors, which is a significant notion of investment in real world.

Chapter Five Conclusion

5.1 Conclusion

"*If I have been further it is by standing on the shoulders of giants.*"
Isaac Newton, 1676

Confronting the uncertainty of the stock market, DCA is a popular investment strategy recommend by professional advisors. Seen from Table 4.14 (Appendix 5), chronologically, the issue has been widely investigated and fiercely debated over forty years (from Wilson 1961 to Chen and Estes 2007) by academic researchers and financial practitioners. They involve diversified points of view through various fashions, such as simple numerical illustrations, historical performances evaluations, simulated scenarios examinations and theoretical model discussion. Yet the researches in DCA strategy are deficient in terms of an analytic summation. The principal objective of the paper is to intensively investigate the DCA investment strategy which has already been comprehensively researched by previous thinkers with considerably controversial academic viewpoints over a long period of time.

Focusing on the existing knowledge of the topic involving methodological issues, research techniques and theoretical theories, 27 out of 40 papers were thoroughly reviewed, which are more relevant to the research topic. Among the papers, eleven articles were identified as belonging to the category that LS is superior to DCA, ten articles were assigned to provide mixed opinions on the performances of DCA and six articles were regarded to support the optimality of DCA. It is found that, academically, there is a minority of researchers are favourable to DCA compared with LS, in contrast with the popularity of DCA among professional finance advisors. In addition, the research was carried on to appraise the literatures in the light of the advantages of LS strategy over DCA strategy in terms of higher expected returns and more risk reductions, immediate investment timing and more flexibility and the fallacy of the favours to DCA, a concentration of mixed arguments focusing on the points of expected returns and risks reducing, investment timing and flexibility and psychological considerations and the dominated advantages of DCA strategy over LS

into dimensions of increased returns and reduced risks, more flexibility of investment and psychological considerations. Nevertheless, there is a fallacy on the consideration of cost advantage of DCA concerning their performances measurements, since the lower average cost is not enough to make sure that one strategy is optimal performance than the others, referring to Greenhut (2006), Wilson (1961) and Marshall (2000).

From the respective of the literatures reviewed, the majority of researchers demonstrated that DCA generates lower returns than LS and more papers observed the optimality of DCA in risk reduction. Especially, Bacon, et al. (1997) Johnson (2004) and William and Bacon (2004) noted that the less the number of the DCA instalments is, the higher the return it generates to clarify the inferiority of DCA in returns. Additionally, there are opposite views regarding the market conditions for DCA, Rozeff (1994) claimed the upward market works better for DCA, on the contrary, Brennan et al. (2005) favour bear market for DCA. Moreover, the disputes on the relationship between DCA performances and volatility in the financial market are fierce: Dubil (2005) demonstrated that DCA works better with higher risky assets, which is opposite to Scherer and Ebertz (2003) Leggio and Lien (2001) and Leggio and Lien (2003) claiming that cost averaging is less valuable in the volatile market with frequent prices up and down fluctuations.

In addition, Monte Carlo simulation was applied to test the summarized and criticized outcomes achieved by reviewing. Armstrong (2005) noted the advantage of simulation that representing the entire distribution of results instead of a single-point estimate, which draw values at random for a number of scenarios to construct a single test. Using the S&P 500, FTSE 100 and FTSE All-Share indices, the empirical test concerned both US and UK financial market and incorporates the consideration for both low and high risks. Most important of all, under the certain assumptions, the simulation results confirmed the literature finding that DCA investment has been underperformed opposed to LS strategy in terms of returns but it performs advantageously to avoid investing risks. However, some results contradict to the claims of the authors. Furthermore, DCA is examined as more favourable for lower volatility assets by comparing with alternative DCA strategies themselves. However, in contrast to LS strategy, DCA provides outperformances for higher volatility

investment due its instinct ability to decrease risks by spreading the money over the given period. Thus it is incautious to assert and identify an absolutely superior investment strategy between DCA and LS strategies.

According to all the results attained and the assumption of positive excess return of the investment, the conclusion will be summarized as follows:

- ☆ It is important to highlight the fallacy on the cost advantage of DCA concerning their performances measurements.

- ☆ DCA strategy is reducing risk strategy. But it is inferior to LS strategy in terms of effectiveness to generate returns.
- ☆ Generally, DCA strategies have better performance by investing in less volatile assets. However, compared with LS, DCA is suitable to be applied for investments with more risky underlying assets due to its significant ability to hedge risk.

- ☆ It is incautious to assert DCA's superiority or inferiority and distinguish DCA from optimal or suboptimal investment strategies. In real world, the application of the DCA strategy greatly hinges on the risk aversion levels of investor.

5.2 Limitations and recommendations

The scope of the research will primarily focus on the performance evaluation of DCA by the comparison with LS by various viewpoints from academics and professionals. The limitation of this study would be the limited studies of literature review of DCA in particular with the restriction on both primary and secondary data collection. Given the aims of the research and the availability of the resources, there would be only certain data focused on assumptions, techniques/methodologies and conclusions and primarily available from the scholarly journals and academic publications.

In addition, from the perspective of scientifically examination, the test results are highly dependent on the certain assumption presumed, especially the zero risk-free interest rate which has been hypothesized to produce a positive expected excess return. Thus, the presupposition has confined the results by focusing the tests under bear market condition. The achieved results basically conform to that of Abeysekera and Rosenbloom (2000), which also provided positive expected excess return by assuming the expected rate of return of 10% and current risk-free rate of 4%.

Thus, with respect to incorporating the under researched points, more researches are required to carry out to test performances evaluation concerning the transaction cost, taxes, dividends, behavioural factors with concentration on the study in the specific area of risk-free assets investment and to verify the performances of different time horizons regarding to the claims of Bacon, Williams and Ainina (1997) Johnson (2004) and William and Bacon (2004).

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Appendices

Appendix 1

Performances Summary

Figure 2.6

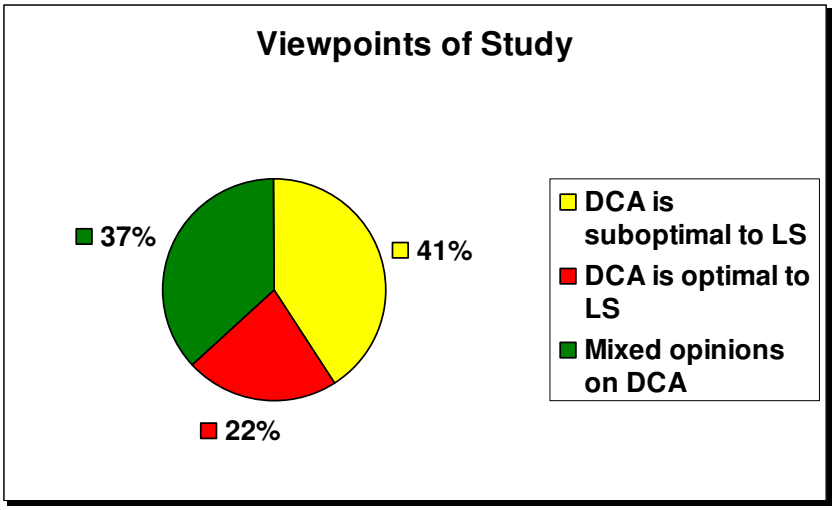

Table 2.1 Viewpoints of Study		
DCA is suboptimal to LS	11	41%
DCA is optimal to LS	6	22%
Mixed opinions on DCA	10	37%
Total	**27**	

Figure 2.7

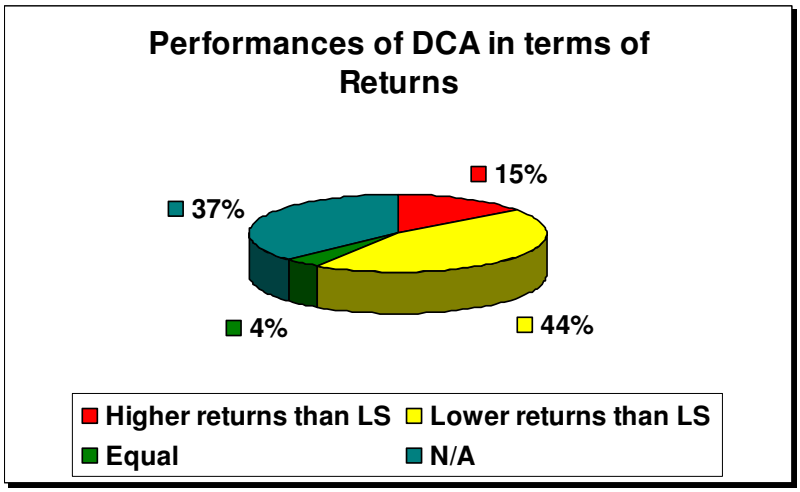

Table 2.2 Performances of DCA in terms of Returns		
Higher returns than LS	4	15%
Lower returns than LS	12	44%
Equal	1	4%
N/A	10	37%
Total	**27**	

Figure 2.8

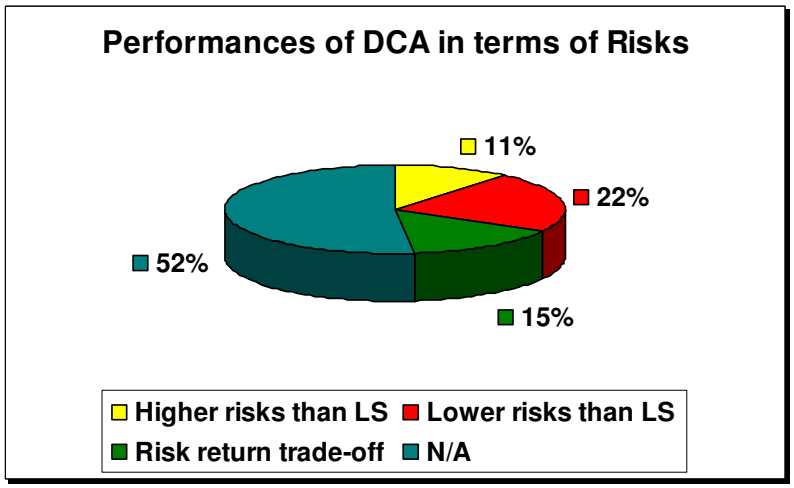

Table 2.3 Performances of DCA in terms of Risks		
Higher risks than LS	3	11%
Lower risks than LS	6	22%
Risk return trade-off	4	15%
N/A	14	52%
Total	**27**	

Figure 2.9

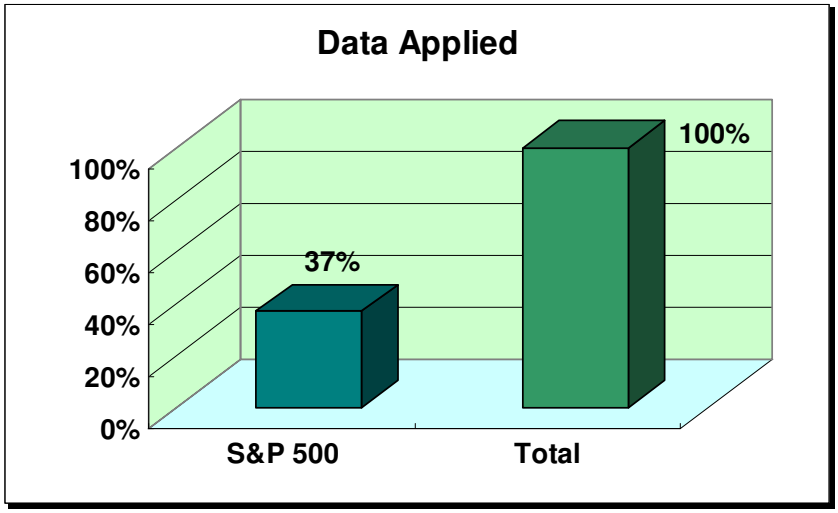

Table 2.4 Data Applied		
S&P 500	10	**37%**
Others	9	33%
N/A	8	30%
Total	**27**	**100%**

Appendix 2

Statistics of Indices

Table 3.2 Calculated Statistics of Indices	Mean of expected return	Standard deviation of return	Mean of expected return	Standard deviation of return
	Monthly	Monthly	Annually	Annually
S&P 500 Index	0.65%	4.10%	**7.80%**	**14.20%**
FTSE 100 Index	0.60%	4.63%	**7.20%**	**16.04%**
FTSE All-Share Index	0.10%	4.12%	**1.20%**	**14.27%**

Statistics of Methodologies

Table 3.3 Research Methods of Study		
Numercial Examples and N/A	3	11%
Descriptive Statistics Calculation	7	26%
Simulation (involving the other methods)	**8**	**30%**
Functions, Formulations and Theories	9	33%
Total	**27**	100%

Appendix 3

Graphical Summation of Literatures

Table 4.1 Papers Classifications	
Purely Theoretical Argument	8
Mainly Empirical Research	14
Theoretical Analysis and Empirical study	5
Total	**27**

Table 4.2 Research methods of study		
Numerical Examples and N/A	3	11%
Descriptive Statistics calculation	7	26%
Simulation (Involving the Other Methods)	**8**	**30%**
Functions, Formulations and Theories	9	33%
Total	**27**	100%

Table 4.3 Assumption for Transaction Cost and Taxes		
Considered	3	**11%**
Ignored	6	**22%**
N/A	18	67%
Total	**27**	100%

Table 4.4 Time Horizon Concerned		
Long-term	13	48%
Short-term	**1**	**4%**
Long-term and Short-term	4	15%
N/A	9	33%
Total	**27**	100%

Table 4.5 Assets Invested		
Risky assets	12	44%
Risk-free assets	**1**	**4%**
Both	14	52%
Total	**27**	**100%**

Table 4.6 Psychological Consideration		
Included	9	**33%**
Total	**27**	**100%**

Appendix 4

Exemplified Calculation

Table 4.7 Exemplified Simulation Calculations by Excel – Risk Solver

	A	B	C	D	E	F	G	H	I	J	K
1	**Spreadsheet Model of DCA and LS strategies**		**Month**	**Units price (£)**	**Units LS**	**Value LS (£)**	**Units DCA**	**Value DCA (£)**	**Value DCA (£)**	**LS minus DCA (£)**	
2	μ	7.77%	**0**	**100**	**240**	**24,000**	**20**	**22,000**	**24,000**	---	
3	σ	14.20%	**1**	102.0677	240	24,496	40	20,000	26,041	(1,545)	
4	$\mu - r =$	7.77%	**2**	105.23999	240	25,258	59	18,000	26,167	(909)	
5	T (year)	0.0833	**3**	105.26433	240	25,263	78	16,000	26,168	(905)	
6	$\sigma\sqrt{T}$	0.041	**4**	112.29348	240	26,950	95	14,000	26,714	237	
7	**Interest Rate: zero**		**5**	113.73876	240	27,297	113	12,000	26,852	446	
8	**Captial (£)**	24,000	**6**	115.53185	240	27,728	130	10,000	27,054	673	
9	**DCA**	2,000	**7**	110.58524	240	26,540	148	8,000	26,410	131	
10	**per installment (£)**		**8**	104.54697	240	25,091	168	6,000	25,514	(422)	
11			**9**	100.63596	240	24,153	187	4,000	24,859	(706)	
12			**10**	98.987536	240	23,757	208	2,000	24,550	(793)	
13			**11**	99.361618	240	23,847	228	0	24,627	(781)	
14			12	**100.87004**	**240**	**24,209**	228	---	22,971	1,238	
15											
16											

Formula Applied	$S_t \sim S_0 \exp([\mu - \frac{1}{2}\sigma^2]t + \sigma\sqrt{t}N_{0,1})$	
Units price (£)	D3	=D2*EXP((B2-B3*B3/2)*B5+B3*NORMSINV(RAND())*SQRT(B5))
Value LS (£)	F3	=(F2/D2)/D3
Units DCA	G3	=B9/D3+G2
Value DCA (£)	H3	=H2-B9
Value DCA (£)	I3	=D3*G3+H2
LS minus DCA (£)	J3	=F3-I3

Table 4.8 - Exemplified Simulation Calculations of Results of DCA and LS Strategies

Spreadsheet Model of DCA and LS strategies		Month	Units price (£)	Units LS	Value LS (£)	Units DCA	Value DCA (£)	Value DCA (£)	LS minus DCA (£)
μ	1.15%	**0**	**100**	**240**	**24,000**	**20**	**22,000**	**24,000**	**---**
σ	13.92%	**1**	99.4428523	240	238,663	401	200,000	259,889	-21,226
$\mu - r =$	1.15%	**2**	99.2441749	240	238,186	603	180,000	259,809	-21,623
T (year)	0.08333	**3**	107.591243	240	258,219	789	160,000	264,839	-6,620
	0.04018	**4**	114.462711	240	274,711	963	140,000	270,258	**4,453**
Captial (£)	24,000	**5**	108.847229	240	261,233	1147	120,000	264,848	-3,615
DCA per	2,000	**6**	111.855043	240	268,452	1326	100,000	268,298	**154**
installment (£)		**7**	108.152659	240	259,566	1511	80,000	263,390	-3,823
Interest Rate: zero		**8**	106.264292	240	255,034	1699	60,000	260,537	-5,503
		9	110.915631	240	266,198	1879	40,000	268,439	-2,242
		10	108.584912	240	260,604	2063	20,000	264,059	-3,455
		11	116.675651	240	280,022	2235	0	280,754	-732
S&P 500 Index		12	116.946446	240	**280,671**	2235	**---**	**261,359**	**19,312**

Spreadsheet Model of DCA and LS strategies		Month	Units price (£)	Units LS	Value LS (£)	Units DCA	Value DCA (£)	Value DCA (£)	LS minus DCA (£)
μ	1.15%	**0**	**100**	**240**	**24,000**	**20**	**22,000**	**24,000**	**---**
σ	13.92%	**1**	105.39519	240	25,295	39	20,000	26,108	-813
$\mu - r =$	1.15%	**2**	100.88086	240	24,211	59	18,000	25,932	-1,721
T (year)	0.08333	**3**	103.67965	240	24,883	78	16,000	26,097	-1,213
	0.04018	**4**	103.29954	240	24,792	97	14,000	26,067	-1,275
Captial (£)	24,000	**5**	106.61991	240	25,589	116	12,000	26,390	-802
DCA per	2,000	**6**	109.20286	240	26,209	135	10,000	26,691	-482
installment (£)		**7**	109.79255	240	26,350	153	8,000	26,770	-420
Interest Rate: zero		**8**	107.92309	240	25,902	171	6,000	26,484	-583
		9	118.11738	240	28,348	188	4,000	28,230	**118**
		10	113.11365	240	27,147	206	2,000	27,289	-141
		11	108.5155	240	26,044	224	0	26,342	-298
FTSE 100 Index		12	110.24062	240	**26,458**	224	**---**	**24,729**	**1,729**

Spreadsheet Model of DCA and LS strategies		Month	Units price (£)	Units LS	Value LS (£)	Units DCA	Value DCA (£)	Value DCA (£)	LS minus DCA (£)
μ	1.15%	**0**	**100**	**240**	**24,000**	**20**	**22,000**	**24,000**	**---**
σ	13.92%	**1**	99.965472	240	23,992	40	20,000	25,999	-2,008
$\mu - r =$	1.15%	**2**	100.25675	240	24,062	60	18,000	26,011	-1,949
T (year)	0.08333	**3**	98.729859	240	23,695	80	16,000	25,919	-2,224
	0.04018	**4**	102.4711	240	24,593	100	14,000	26,220	-1,626
Captial (£)	24,000	**5**	110.14434	240	26,435	118	12,000	26,985	-550
DCA per	2,000	**6**	109.09564	240	26,183	136	10,000	26,861	-678
installment (£)		**7**	119.0876	240	28,581	153	8,000	28,222	**359**
Interest Rate: zero		**8**	108.25857	240	25,982	171	6,000	26,565	-583
		9	113.16288	240	27,159	189	4,000	27,406	-247
		10	117.07226	240	28,097	206	2,000	28,146	-48
		11	111.79958	240	26,832	224	0	27,058	-226
FTSE All-Share Index		12	116.13924	240	**27,873**	224	**---**	**26,031**	**1,842**

Appendix 5

Table 4.14 Summary of Literature Review

Author	Date	Type of research performed	Study Content/ standpoint	Assumptions	Method / Techniques	Asset(s)	Data Collection	Comments	Evaluation (Criticism)
Wilson, G.w.	1961	Theorectial analysis	Investigate the accelerated dollar averaging	**1.** A firm requires certain units Q of shares **2.** Finite time of investing periods **3.** A probability density function for each day equal to f(x)=1/(b-a), x is the price prevailing during period I, x=[b,a]	functions of the price and derivative of formulas	Each purchasing opportunity	N/A	Simple dollar averaging is superior to a policy of buying A/N units per period, because DCA makes actual purchases in any period more sensitive to price.	provides us a simplified discussion about dollar averaging, focusing on the analysis of accelerated dollar averaging based on the acknowledgement of simple dollar averaging.
Pye, G	1971	Theorectical arguments	Minimax policies for dollar averaging	**1.** A given sum of dollars to invest **2.** Share prices follows an arithmetic random walk	Formulations of nonsequential policies and sequential policies	Stocks	N/A	*Conventional wisdom of dollar averaging is related to hedging against large regrets rather than unfavorable outcomes.*	His study of the suboptimality of DCA as one of the gradual policies contributed to the influential arguments of Constantinides (1976) on the suboptimality of DCA strategy. He agreed the advantage of dollar averaging in terms of psychological considerations, such as the effect of a regret criterion, rather than the out-performances for expected returns or terminal values achieved.

Appendix 5

Table 4.14 Summary of Literature Review

Author	Date	Type of research performed	Study Content/ standpoint	Assumptions	Method / Techniques	Asset(s)	Data Collection	Comments	Evaluation (Criticism)
Constantinide, G. M.	1979	Theorectical arguments	The suboptimality of DCA as an investment policy, which is nonsequential and depends both on the total and the composition of the wealth of the investor	**Perfect market assumptions: 1.** Investor is a price taker **2.** No personal tax **3.** No transaction costs **4.** Expected utility of consumption is maximized **5.**	Theorectical analysis based on previous study, using hypothetical examples	Assumed inherited wealth in shares: simple two investment opportunities	Assumptions and literatures	The DCA policy is dominated by a sequential optimal investment policy and an optimal non-sequential investment policy	Examines the performance of DCA and LS based on historical evidence. He claims that the return of DCA is disproportional to the number of DCA instalments: the sooner to invest, the higher the realized return to gain
Knight, J. R. & Mandell, L	1993	Theoretical arguments, numerical simulation and empirical illustration	Investigate the effects of market timing and performances of DCA based on historical data	**1.** An initial stock of wealth invested in the riskless asset **2.** Investors know the balance between risky and riskless assets **3.** An investor's optimal balance is 50-50 **4.** Transaction cost would vary inversely with the size and directly with the frequency of investment.	Graphical analysis, Monte Carlo Simulation by utility function and empirical test in terms of stadard deviation and mean annualized return	Risky assets: S&P 500 and risk-free asset: T-bills.	New York Stock Exchange data. Monthly return from 1962 to 1982, giving a total of 240 holding periods	There is the lack of any advantage of DCA relative to two alternative investmetn strategies. *Our numercial simulations and empirical evidence, in consonance with our graphical analysis, both favor the Optimal Rebalancing and Buy and Hold strategies over DCA.*	Arguments are strongly based on the assumptions: inverse effect on transaction costs of DCA and known best asset allocation to maximize utility. Discussions focus on returns leaving the standard deviation aside.

Appendix 5

Table 4.14 Summary of Literature Review

Author	Date	Type of research performed	Study Content/ standpoint	Assumptions	Method / Techniques	Asset(s)	Data Collection	Comments	Evaluation (Criticism)
Rozeff, M.S.	1994	Empirical research by examples and simulation test	DA is mean-variace inefficient compared with LS	**1.** Stock market has a positive expected risk premium **2.** Returns follow a random walk model and are multivariate normal. **3.** No equalization of returns for DA and LS or equalization of returns for DA and LS	A two-period example, formulas for multiple T periods and Simulation to compare returns, standard deviation and Z-statistics	S&P 500 Index and small-firm portfolio	Monthly data, 1926-1990, sourced from Ibbotson Associates	"Invest without delay." LS policy causes the invested funds more independent return realizations. DA by spreading the investment out over time suffers a performance penalty.	Examines the performance of DA and LS across different investment periods, also with the correct risk adjustment between the two investment policies. But the conclusion is just partial convinced, only focuses on the increasing stock market but not considering for both of the downward and upward market tendencies.
Thorley, S	1994	Theorectically criticism and empirical illustration	Explain the fallacy of the performances of DCA	**1.** Risk premium to be zero **2.** Return calculated by Internal Rate of Return **(IRR) 3.** Ignore the return on cash not invested in the stock **4.** A perfectly random or efficient market or nonrandom price changes	Emprical illustration in terms of expected returns, standard deviation, geometric mean, arithmetic mean, strategy's beta, Sharpe's measure and Treynor's measure	Stock or mutual fund	S&P 500 Index and Treasury bill data from 1926 to 1991	*DCA performs well under a seemingly plausible but irrelevant criterion. DCA has no value and may actually be harmful as an investment stragegy.*	Present a fundamental criticism on DCA based on prior studies. Completely contradict the benefits of DCA subject to the lower return and higher risk.

Appendix 5

Table 4.14 Summary of Literature Review

Author	Date	Type of research performed	Study Content/ standpoint	Assumptions	Method / Techniques	Asset(s)	Data Collection	Comments	Evaluation (Criticism)
Samuelson	1994	Theorectical arguments	Long-term case for equities	**N/A**	N/A	Equities	N/A	*Sleeping well for irrational reasons, is as good as sleeping well for rational reasons.*	His argumenst diminished the advantage of DCA from the perspective of psychological considerations.
Statman, M	1995	Theorectical arguments	The behavioral framework for DCA	**1.** There is an equal chance for an up-market or down-market in the coming period.	Utility function and prospect function and numerical examples	Stocks	Assumed	*DCA may not be rational behavior, but it is perfectlynormal behavior. The practice of DCA will persist.*	He theoretically provided further development of prospect theory and predominant exploration on the behavioural finance consistent with DCA in contrast with standard finance.

Appendix 5

Table 4.14 Summary of Literature Review

Author	Date	Type of research performed	Study Content/ standpoint	Assumptions	Method / Techniques	Asset(s)	Data Collection	Comments	Evaluation (Criticism)
Bacon, P. W., William, R.E. & Ainina, M.F.	1997	Numerical arguments based on historical evidence	Whether DCA works for bonds	**1.** Long-term investment **2,** Holding a large sum of endowment to investment **3.** Interests are accumulated **4.** An overall return equal to income plus the capital gains returns	Examples and tables to compare the AHPR (Annualized Holding Period Return) of LS and DCA (12/6/3-month averaging including accumulated interest of risk-free assets)	Treasury bonds, corporate bonds and 90-day Treasury bills	Monthly rates of return for both income and capital gains, 1926-1995, sourced from *Ibbotson Associates' 1996 Yearbook*	DCA is unlikely to produce investment results superior to LS investing, even after adjusting for risk.	Based on historical evidence, they examine the performance of DCA on bonds investment, in comparison with LS. As most of the researches focus on investing inn equities, their study does fill the gap of bonds in literature
Khouja, M & Lamb, R.P	1999	Theorectical arguments and numerical analysis	Determine the optimal transaction size to maximize returns for DCA investment strategy	**1.** Most DCA investors purchase equity at regular and predictable intervals **2.** During captial buildup between transactions, funds could be invested in a money market account **3.** Initial invested funds are accumulated in the money market account **4.** Equity returns are assumed more than that earned in the money market	Numerical examples and sensitivity analysis	securities	Assumed	*A simple dollar cost averaging strategy must include the impact of transaction costs, otherwise returns can not be maximized.*	Provide additional significant insights into the impacts of transaction costs on DCA investment strategies for investors. But no comparison with alternative investment strategies.

Appendix 5

Table 4.14 Summary of Literature Review

Author	Date	Type of research performed	Study Content/ standpoint	Assumptions	Method / Techniques	Asset(s)	Data Collection	Comments	Evaluation (Criticism)
Israelsen, C.L	1999	Empirical examination	LS doesn't always result in superior returns over DCA.	**1.** Ignore all taxes and loads **2.** Dividend and capital gain distributions were reinvested	Numerical illustrations	35 largest equity mutual funds	Morningstar Principia Pro (October 1998) for 10 years	*Funds with lower standard deviations of annual return (i.e., equity income and balanced funds) may actually be better suited for DCA.*	Support DCA strategy, but results are condined on specific date and assets, which are not general for an overall investing situation.
Braselton, P. J., Rafter, A. J. Humphrey, P. and Abell, L. M.	1999	Empirical examination	With the random walk with stock prices, compare LS and DCA	**1.** An investor invest monthly for 5 years with an initial investment in an S&P 500 index **2.** The price fluctuates according to dist **3.** The remained money is invested in a fixed-income investment to earn interest rates.	Standard Mathematica Package Statistics 'ContinuousDistributions', built-in function NonLinearFit and simulations	Daily closing values of the S&P 500 Index from January 1, 1926 to June 11, 1993	Internet	*If the funds are available, lump-sum investing can be expected to produce substantially higher returns than dollar-cost averaging.*	The study simply included little assumptions that an investor has an initial investment funds and interest rates accumulated during the investing periods, however, especially excluded the supposition of stock market to be upward or downward, which offering an unlimited measurement results.

Appendix 5

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Abeysekera, S.P & Rosenbloom, E.S	2000	Empirical study	Help an investor to decide between a LS investment strategy and a DCA investment strategy.	**1.** Investors have a initial sum of money to invest **2,** A lognormal distribution of the stock price **3.** T-bill rates followed a random walk over a one-year period **4.** Monthly stock market returns were independent **5.** Parameters of the lognormal distribution are constants **6.** Treat simulation model as random variables	Monte Carlo simulation	Risky assets like S&P 500, Risk-free asset like Treasury bills	Monthly returns of the S&P index between 1926-1997 and Treasury bill rates between 1934 and 1998	*The choice between the two strategies should be conditioned by the risk/return trade-offs from the investor's perspective, which are provided a more complete picture by simulation. The advantage of a simulation model is tis flexibility andn ease of modification at the time of invesment.*	They provide the discussion about the advantage of simulation. They insist DCA's underperformance but stress its risk reduction effec. And propose that comparison result between investment strategies is conditioned on investors' own perspective.
Marshall, P.S.	2000	Empirical research	Compare VA vs DCA and Random Investment and demonstrate VA dominates the others	**1.** Ignore the transaction costs and taxes **2.** Annual time periods **3.** No market price trend **4.** A constant investment amount for DCA, a 10% expected return on VA's investment, a 'random' amount invested in random investing and a 20 quarer investment time horizon	Internal rate of return (IRR) and simulations to calculate the mean and standard deviation of IRR, and F-Test	shares	random 20-quarter prices for 5 years by the S&P 500 index from January 1, 1966 to March 1, 1989	VA does actually provide a performance advantage over DCA and random investment techniques, without incuring additional risk. The higher the price variability and the longer the investment time horizon the better.	The result is in contrary to Greenhut's study on DCA's lower cost numerical illusion, without direct comparison between DCA and LS.

Appendix 5

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Vora, P.P. & McGinnis, J.D	2000	Empirical research	The asset allocation decision in retirement learning from DCA	**1.** DCA into stocks is sub optimal **2.** Retirees are primarily interested in mazimizing their consumption stream **3.** The retiree has wealth at the bginning of his retired life which is invested in a stock portfolio **4.** all the money is spent by the end of the retirement period **5.** Inflation considered	Consumption formulation	T-bonds and stocks	Monthly returns on the CRSP VW portfolio	*Individuals should seriously consider remaining in stocks even after retirement, particularly at long retirment horiozns.*	All their results are strongly based on the assumption that DCA for stock investing is inferior, which seemingly made their converse utilization of DCA concept –"dollar cost disinvesting" logical. As a pinpoint of this paper, they noted the favour of DCA strategy for investors as retirees with limited amount of money for investment.
Leggio, K.B & Lien, D	2001	Empirical tests	Find loss aversion NOT explain the existence of DCA by comparing with alternative strategies: LS, VA and BH	**1.** Investors have a fixed sum of money to invest **2,** Investment is for 1-year time frame **3.** The underlying asset of LS is risky. The funds invested of DCA is risky asset and the not invested funds are risk-free. **4.** Constant relative risk aversion	Prospect theory, investor utility function and performances ranking metrics in terms of mean, S.D., Sharpe ratios, value functon and p-value	Large and small socks and T-bills	30 observations: Monthly returns from January 1970 to December 1999. Data comes from Ibbotson and Sinquefeld (2000): *Stocks, bonds, bills and inflation: Valuation edition 2000 yearbook*	*DCA is not a mean-variance efficient method of investing. DCA may fail to be an optimal investing strategy for riskier assets because loss aversion and risk aversion coefficients are overestimated.*	They provide explicit empirical test. From the perspective of data employed, they call into the tests covering both the underlying assets with higher and lower volatility. Moreover, they take into account the "anomalous situations", such as 'the January effect'. The viewpoint that LS yields higher mean excess return is corresponding to that of Rozeff (1994).

Appendix 5

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Atra, R.J & Mann, T. L	2001	Empirical research	Examine the performace of DCA compared with LS in the concept of seasonality of security returns	**1.** Remain investment funds are invested in risk-free asset **2,** In any given investing month, the strategies could be implemented **3.** The programs befin in the month indecated and occur each year of the sample **4.** Ignore the transaction cost and tax	A self-financing portfoli and Sharpe ratio	Stock indecies and T-bills	Monthly total return data from 1970 to 1998 from Morgan Stanley Capital International: World, Europe, EAFE, Pacific, Japan indecis and U.S. and U.S. 90-day Treasury-bill	DCA is not an investment technique for all season. DCA investing offers no benefit in terms of a risk/return trade-off.	Based on historical evidence, he provides an overall discussion for market timing and emprically investigate the performance of DCA compared with investment up-front for two decades. The research includs both upward and downward stock market and covers various stock index as well as bond index. However, the results are only based on the certain assumption and doesn't provide explicit analysis of the hypothesis test result.
Milevsky, M.A & Posner, S.E	2003	Theorectical arguments	Demonstrate DCA akin to a zero-strike arithmetic Asian option, approve the expected return of DCA exceeds that of LS and argue the behavioral understanding of DCA related to continuous-time finance	**1.** There is a mount of wealth including both risk-free and risky asset **2.** Not yet invested funds' interests are continuously compounded **3.** IIndividuals invest in positive drift asset **4.** The underlying security ends up at a fixed pre-determined value	Model of Geometric Brownian Motion **(GBM)**	Risk-free asset and risky asset	Assume initial amount of wealth and initial value of stock equal to 1 and interim interest rate equal to zero	*DCA performs well under a seemingly plausible but irrelevant criterion. DCA has no value and may actually be harmful as an investment stragegy. DCA with certain volatility produce a higher conditional expected value than LS, which increases with higher levels of volatility.*	Their conclusions are strongly based on the assumption that the investors are able to predetermine the final value of the underlying securities, which is unreliable in the real world. Thus the fundamental of the conjecture is practically unstable.

Appendix 5

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Leggio, K.B & Lien, D	2003	Empirical study	Compare DCA with alternative investment strategies: LA and VA, using risk-adjusted performance measures	**1.** Investors have a fixed sum of money to invest **2.** Investment is for 1-year time frame **3.** The underlying asset of LS is risky. The funds invested of DCA is risky asset and keeps the remaining wealth in risk-free asset	Performances ranking metrics in terms of mean, S.D., Sharpe ratios, Sortino ratio and Upside Potential ratio	Risky assets: large company stocks: S&P 500, Ibbotson small-company stocks, long-term government bonds and long-term corporate bonds. Risk-free asset: U.S. Treasury bills	Data of monthly returns from 1926-1999, comes from *Ibbotson Associates Valuation Edition 2000 Yearbook*.	*For investment advisors, the results fail to support dollar-cost averaging as a consistently superior method of asset allocation.*	They conduct the performance measurements by risk-adjusted return and pointed out that the popular Sharpe ratio generates reserve ranking results compared with the "more accurate" Sortino ratio and UPR. They explore that there is no significant difference between the reported results of 74-year period and 30-year period. They amply analyze two presumed portfolios concerning the diversification strategy.
Scherer, B & Ebertz, T	2003	Mathematically theorectial arguments	Cost averaging is an expensive strategy for maximising terminal wealth	**1.** Mean of return is more than risk-free rate **2.** States of the world are equally likely **3.** Utility is a concave function **4.** A given dynamic strategy varying between equity and cash with a fixed rule **5.** Noninvested money earns interest rate	Simulation, state price deflators, utility function, Black & Schole formula and payoff distribution pricing model	Stocks, bond and European calls	Assumed	*Cost averaging is ineffficient.*	They provided additional insights on the performance evaluation from the perspective of asset pricing theory. They refuted most of the popular studies on the measurement of cost averaging, nevertheless, lacking the sufficient argumentation to convince their points of view. Moreover, the approach applied to prove is unapparent stated. Overall, their conclusions are based on rough arguments with insufficient statistical support.

Appendix 5

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Williams, R. E. & Bacon, P. W.	2004	Empirical study based on historical evidence	LS beats DCA: Invest a large cash endowment immediately in stocks while not gradually shift the funds into the market	**1.** Long-term investment **2,** Holding a large sum of endowment to investment **3.** Interests are accumulated **4.** An overall return equal to income plus the capital gains returns	Examples and tables to compare the AHPR (Annualized Holding Period Return) of LS and DCA (12/6/3-month averaging including accumulated interest of risk-free assets)	S&P 500 Index and 90-day Treasury bills	Monthly total rates of return, 1926-1991 (into 1926-91, 1950-91 & 1970-91 three periods), sourced from *Ibbotson Associates' 1992 Yearbook*	For the entire 65-year period, 2/3 of the time LS significantly outperformed DCA, but during the 1970-91 stock market poor performance period, LS worked less superb though still dominated DCA.	Examines the performance of DCA and LS based on historical evidence. He claims that the return of DCA is disproportional to the number of DCA installments: the sooner to invest, the higher the realized return to gain
Bierman, H. JR. & Hass, J.E	2004	Theorectically criticism and empirical studies	Comparison between LS and DCA, involving behavioral considerations	**1.** Expected return higher than the cost of equity **2.** Expected return equal to the cost of equity **3.** An opportunity cost of not investing immediately **4.** stock price trend is upward or downward	Literature review and simple mathematics examples	shares	Assumptions of invesment fund and share prices	DCA does not reduce risk or increase expected return in a normal situation.	Criticize the viewpoints from various scholars who are for or against DCA, provide critical study on DCA's behavioural advantages, propose further views upon DCA's suboptimality but without explicit analysis and illustration

Appendix 5

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Johnson, K (Working paper)	2004	Empirical research	Investigate the effects of market timing and performances of DCA based on historical data	**1.** dividend excluded from the calculation of return **2,** Missing the best and/or worst investing days	Literature review, empirical researched in terms of compound annual return, average annual return, daily return and standard deviation and thpothesis test	Shares or bonds	Daily S&P 500 returns from January 1, 1982 to December 31, 2001, and also NASDAQ Composite Index, Dow Jones Composite Index, DJ Utility Index, DJ Utility, 30-Year T-bonds and baa Long-term bonds from Economagic.com	DCA usually falls short of an investment up front. Make the largest up-front investment possible, even consider borrowing.	Based on historical evidence, he provides an overall discussion for market timing and emprically investigate the performance of DCA compared with investment up-front for two decades. The research includs both upward and downward stock market and covers various stock index as well as bond index. However, the results are only based on the certain assumption and doesn't provide explicit analysis of the hypothesis test result.
Dubil, R	2005	Theorectical arguments illustrated by empirical methods	DCA strategies can significantly reduce the investment risk, which is optimal than invest up front for underlying high-risk assets	**1.** Underlying asset is a risky stock **2.** Price subject to random fluctuations **3.** Stochastic variables and functions of the path of stock price	Derived mathematical formulas to analyze the average and the volatility of stock prices, and Simulations to compare mean terminal value, standard deviation and shortgall probability	Asian options, investments, e.g. S&P or Nasdaq and individual stock	Two different final horizons: 5 and 15 years, five-time and five-year DCA plan	Automatic strategies like DCA guarantee the significant reduction of the investment risk for high-risk assets. Long-term investors should choose LS strategies for low-risk.	Considers both low-risk and high-risk assets and various investign scenarios with both relatively longer and shorter time horizons. However, he just highlighted the effecs on risk reduction other than the expected return maxmisation.

Appendix 5

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Brennan, M.J, Li, F and Torous, W.N	2005	Empirical research	DCA is heruistic and provides survival value, but not simply assist irritional investing behaviour	**1.** Transactions costs and market impace ignored **2.** Standard assumptions about capital markets **3.** Investors hold the market portfolio and to purchase a marginal amount of a randomly chosen additional stock **4.** The initial diversified portfolio of common stocks is optimallly levered **5.** No special information about stockreturns	Monte Carlo simulation	Shares and T-bills	CRSP value-weighted or equal-weighted indices over the period 1926 - 2003	DCA is a heuristic, which has been almost entirely overlooked by academics and is suboptimal under standard assupmtions about capital markets.	It is noticeable that they provided an additional insight on the heuristic value of DCA and highlighted its benefit on the extra stock investment of a well-diversified portfolio. But their conclusion about the advantages disappearance of DCA is heavily resulted from the assumption of the initialled optimal market portfolio, which is difficult to achieve in the real world.
Greenhut, J.G	2006	Theorectical arguments and numerical examination	Compare the DCA and LS by examining the behaviour of stock volatility. See DCA to be neutral compared with LS.	**1.** Considr the dividends of shares **2.** Capital gains are constant **3.** Concern a combination of cyclical variations in interest rates, risk assessment, and potential economic growth	Gordon model or constant growth model	Shares and T-bills	Random 1,605 publicly traded corporations in U.S., crossing industries and style. Monthly closing prices from December 1995 to December 2004	In the absence of upward or downward stock market trends, DCA and LS provide equivalent results.	Provide additional insight for the investigation of DCA from the perspective of mathematical exposure. However, they made their conclusion that DCA strategy performs equitable to LS strategy simply in the sense of averaging stock prices, regardless of other aspects, such as the possible psychological advantages.

Appendix 5
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Chen,H. & Estes, J.	2007	Empirical research	Value averaging is better than DCA	**1.** Initial capital can enjoy a 5% average annual return **2.** the participants themselves monitor the portfolio balance and conduct the VA investing, thus no additional transaction expense or management fees	Monte Carlo simulation and modified Sharp ratio and modified Sortino ratio	T-bills and S&P 500 index	N/A	*Results from both historical data and simulations show the 401(k) VA strategy beats the DCA strategy by generating a higher terminal value for the 401(k) retirement account.*	As claimed, DCA is more suitable for investors with a low annual target growth rate that less than 8 percent or a high annual rate that more than 12 percent. They noted the importance of terminal returns as an effective measurement, so did the concerns on risk/reward trade-offs comparisons.