Does Market Timing Beat Dollar Cost Averaging?

Yan He and Junbo Wang

Abstract

This paper explores several methods for investing monthly cash contributions in an equity index, such as the S&P 500 or the Nikkei 225. The dollar cost averaging (DCA), three variations of market timing (MT1, MT2, and MT3), and 12-month perfect foresight (PF) are examined, and they are built on the same assumptions, such as monthly cash inflows, no borrowing of cash, and no selling of equity. The PF outcomes, unachievable by human beings, serve as optimal boundaries. Our results show that in both the U.S. and Japanese markets, the PF dominates the DCA, while the MTs tend to deliver similar results as the DCA. Thus, the DCA seems to be a compelling investment method.

JEL classification: G10
Keywords: Dollar cost averaging; Market timing; Perfect foresight

I. Introduction

Dollar cost averaging (DCA) is a popular investment method in real-world practice. However, in the research literature, the DCA seems less effective than the lump sum (LS), asset allocation (AA), and various market timing methods. Specifically, we categorize the research literature into three veins as follows.

First, the DCA seems inferior to the LS and AA methods. Constantinides (1979) points out that in a rational expectations framework, the LS is an optimal strategy in which 100% of total wealth is invested in risky assets at the beginning. The DCA is suboptimal, in which the total wealth is divided into a series of small investments in risky assets over time. Rozeff (1994) argues that if the market has a positive expected risk premium, the LS policy is superior to the DCA policy. Leggio and Lien (2003) find that the DCA consistently remains an inferior strategy to the LS, using risk-adjusted performance measures. Bierman and Hass (2004) illustrate that if the cash fund is currently available, the optimum decision is to invest the entire sum, and dividing the initial sum into segments for future investment is not recommended. Panyagometh and Zhu (2016) demonstrate that the DCA is analogous to the AA strategy in which about 50% to 65% of total wealth is invested in risky assets once at the beginning and the rest in riskless assets. They find that the AA strategy has a better risk-return tradeoff than the DCA.

Second, the DCA seems inferior to various market timing methods, which contain rebalancing, value averaging, augmented DCA, enhanced DCA, modified DCA, etc. Brennan, Li, and Torous (2005) document that the DCA is dominated by the rebalancing strategy in which 50% of wealth is invested in the market portfolio, and 50% in cash, and the portfolio is rebalanced monthly to maintain the proportions. Chen and Estes (2007) show that the value-averaging strategy generates

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a higher terminal value for the 401 (k) retirement portfolio than the DCA. Chen and Estes (2010) compare the performances of three strategies in the 401 (k) plan framework: the DCA, value averaging, and proportional rebalancing, and report that value averaging generates a higher terminal value than the other two strategies. Lai, Tseng, and Huang (2016) point out that value averaging, often combined with portfolio rebalancing, is superior to the DCA. Richardson and Bagamery (2011) augment the DCA by investing more in the month following a down market and less in the month following an up market. Dunham and Friesen (2012) introduce the enhanced DCA, which invests a fixed additional amount after a down month and reduces the investment by a fixed amount after an up month. Lin and Xu (2016) present the modified DCA that outperforms the DCA across all of the international stock markets investigated. Kapalczynski and Lien (2021) propose the augmented DCA that is more aggressive if the economy is expanding and more conservative if the economy is contracting.

Third, the DCA may become a preferred method under certain situations of markets and investors. Statman (1995) points out that the DCA is consistent with the elements of behavioral finance: prospect theory, aversion to regret, cognitive errors, and self-control. Atra and Mann (2001) find that the DCA seems superior to the LS when invoked from February to September, yet inferior when started from October to January. Dichtl and Drobetz (2011) argue that the DCA is attractive for prospect theory investors, and the loss aversion and probability weighting are important in explaining the popularity of the DCA. Grable and Chatterjee (2015) reveal that when working with clients with less financial risk tolerance, the DCA provides a way to outperform if a bear market, rather than a bull market, emerges. Cho and Kuvvet (2015) advise that the DCA can be used to lower investment risk. Luskin (2017) reports that the DCA is superior to the LS in certain periods of flat or downward-trending market performance. Smith and Artigue (2018) demonstrate that the DCA can diversify investment risk across time.

In this paper, we explore several methods for investing a series of monthly cash contributions in an equity index over a long horizon. It is assumed that investors do not possess lump-sum cash at the beginning, cannot borrow cash, and cannot sell equity within the investment horizon. The equity index can be either the S&P 500 or the Nikkei 225. Monthly data are used, ranging from December 1989 to December 2019. We choose the equity indexes of the U.S. and Japan because their returns are very different.[1] Our investment methods include the DCA, three variations of market timing (MT1, MT2, and MT3), and 12-month perfect foresight (PF). These methods are built on the same set of assumptions. The outcomes of the methods are mainly measured by the net return in the entire period. The PF outcomes, unachievable by human beings, serve as optimal boundaries.

Our study yields the following findings. In both the U.S. and Japanese markets, the PF indeed dominates the DCA, while the MTs tend to deliver similar results as the DCA. Additionally, the statistical tests of 5-year, 10-year, and 20-year rolling periods produce no evidence of any consistent and significant advantage of the MTs against the DCA. Thus, the DCA seems to be an effective investment method.

[1] See Table 1 for the % change in price from Dec 1989 to Dec 2019, the mean of monthly returns, and the median of monthly returns. As shown, the returns of the U.S. are much higher than those of Japan.

II. Data and Methods

II.1. Data sample and investment assumptions

Our data sample contains monthly prices of the S&P 500 and Nikkei 225 indexes. The time period stretches from December 1989 to December 2019. In addition, the month-by-month rolling periods are also examined, including the 5-year, 10-year, and 20-year rolling periods.

We set up the assumptions below for investing a series of monthly cash contributions in an equity index.

- The time horizon for cash contributions and equity investments is 30 years (360 months), covering from January 1990 to December 2019.
- An amount of 10,000 cash contribution occurs monthly in the same currency of the equity index. Each contribution can be invested in the equity index immediately, saved as cash, or partially invested and partially saved.
- Investors can only use the cash contributions currently received and previously saved to buy the equity index. They cannot borrow cash to invest.
- Investors can only buy and hold the equity index. They cannot sell the equity index within 30 years.
- Cash savings earn 0% interest rate.

II.2. Investment methods

Based on the assumptions above, we apply and compare several investment methods, including the DCA, MT1, MT2, MT3, and PF. Please note two issues here. First, our study does not employ the LS (or AA) method, which would require 100% (or 50%) of total cash contributions in 30 years invested one time in January 1990. It is impossible to hold such a large amount of cash at the beginning due to the assumptions of monthly cash contributions and no borrowing. Second, our study does not conduct rebalancing or value averaging due to the assumptions of no borrowing and no selling. Next, we discuss the DCA, MTs, and PF one by one.

First, the DCA method is to invest 10,000 in an equity index monthly, where the cash contribution and the equity index are in the same currency. Thus, each cash contribution is invested entirely and immediately, leading to zero cash savings. In the real world, the DCA is a widely applied method, and it can be set up automatically for investments in mutual funds and certain types of pension funds.

Second, the three market timing methods (MT1, MT2, and MT3) deviate from the DCA by investing less (more) than the monthly cash contribution if the equity index has risen (declined). These MT methods are subject to the constraint of available cash. They are to invest a varying amount of cash in an equity index monthly, but they calculate the invested amount differently. The MT1 calculation is:

$$\text{minimum } [10{,}000+s,\ (1-r_m)*10{,}000],$$

where s is the cumulative cash savings from the previous months, and r_m is the monthly return of the equity index. The first term, 10,000+s, denotes the cash constraint. The second term, $(1-r_m)*10{,}000$, represents the potential amount that could be invested without any cash constraint. The minimum of the two terms is the actually invested amount. In specific, if the equity index has risen and the monthly return is positive, the invested amount will be less than 10,000. If the equity index has stayed the same and the monthly return is zero, the invested amount will be equal to

10,000. If the equity index has declined and the monthly return is negative, the invested amount, which is constrained by the amount of cash currently received and previously saved, will be equal to or more than 10,000.

The MT2 and MT3 distinguish the first month from the following months in a year. For the amount invested in the first month of a year, the MT2 computation is the same as that of the MT1, whereas the MT3 computation is:

$$\text{minimum } [10{,}000+s, (1-r_a)*10{,}000],$$

where r_a is the annual return of the equity index. For the amount invested in each following month of the year, the MT2 and MT3 definitions are the same:

$$\text{minimum } [10{,}000+s, (1-r_m)*\text{the previous invested amount}].$$

Overall, the MT strategy may or may not defeat the DCA. If equity prices stay flat and fluctuate, the MTs might lead the DCA because the MTs tend to buy at lower prices than the DCA. However, if equity prices go up persistently, the MTs might fall behind the DCA because the MTs tend to buy fewer shares than the DCA. In real-world practice, the MTs seem to involve complicated executions, which may not be conducted automatically for long-term investments. Therefore, unless the MTs beat the DCA consistently and significantly, the DCA will remain an effective method.

Third, the PF method is to correctly foresee the following 12 monthly prices of an equity index so that a decision can be made about whether to invest immediately or in the future. Namely, this method guarantees that every investment, under the cash constraint, occurs at the lowest price of the current and next 12 months. Let s_0 be the cumulative cash savings from the previous months that can be invested in the current month, and s_1 be the cumulative cash savings from the previous and current months that can be invested in the next month. If the current equity price is lower than or equal to the lowest price of the next 12 months, the invested amount of the current month will be $10{,}000+s_0$, and s_1 will be zero. Otherwise, the invested amount of the current month will be zero, and s_1 will be $10{,}000+s_0$. Since humans cannot correctly predict equity prices in the coming months, the PF method is not meant for real-world practice. In this paper, we use it to specify the optimal boundaries of investment outcomes. That is, the DCA and MT results are expected to be worse than or the same as the PF results.

Finally, using the first 24 months as examples, we show the results of periodical invested amounts, calculated respectively according to the MT1, MT2, MT3, and PF methods. See Appendix A for these month-by-month examples from January 1990 to December 1991.

II.3. Investment outcome measures

The total cash contributions in 30 years are 3.6 million, all or parts of which are invested in an equity index of the same currency at various times. At the end of 30 years, investors will hold a portfolio of the equity index and cash, where the cash amount may be zero or positive. The portfolio's ending value may or may not exceed 3.6 million, depending on both the equity index performance and the investment method. After 30 years, investors may liquidize the portfolio and purchase an annuity to receive regular income.

Given the above arrangement, the most important outcome measure is the Net Return in the entire period, defined as:

$$(\text{Ending Value} - \text{Total Cash Contributions}) / \text{Total Cash Contributions},$$

where the Ending Value is calculated as the sum of the ending equity value and ending cash. The ending equity value equals the multiplication of the ending equity index price and the total shares purchased in the entire period. The ending cash equals the difference between the total cash contributions and the total invested amounts in the entire period. A positive (negative) Net Return implies that the equity investment creates (destroys) value. A significantly higher Net Return suggests a better method when different investment methods are employed under the same assumptions and the same equity index performance.

Furthermore, two additional measures, the Average Monthly Return and the Modified Sharpe Ratio, are explored and used as references. The Average Monthly Return refers to the mean of monthly portfolio returns. The Modified Sharpe Ratio denotes the risk-adjusted average monthly return, calculated as:

$$\text{Average Monthly Return} / \text{SD},$$

where SD is the standard deviation of monthly portfolio returns. Here the average monthly portfolio return is compared with the 0% cash return rather than the risk-free rate of Treasury bills. For different investment methods, a significantly higher average monthly return or risk-adjusted average monthly return may indicate a better method, if this method generates a significantly higher net return in the entire period. Thereby, a better method must deliver a significantly higher Net Return, while it may or may not provide a significantly higher Average Monthly Return or Modified Sharpe Ratio.

III. Empirical Results

III.1. The entire period

Figures 1 and 2 display monthly prices over the entire period. In Figure 1, the monthly prices of the S&P 500 Index show a broadly upward trend. In Figure 2, the monthly prices of the Nikkei 225 Index present a chiefly volatile picture.

Figure 1. Monthly Prices of the S&P 500 Index

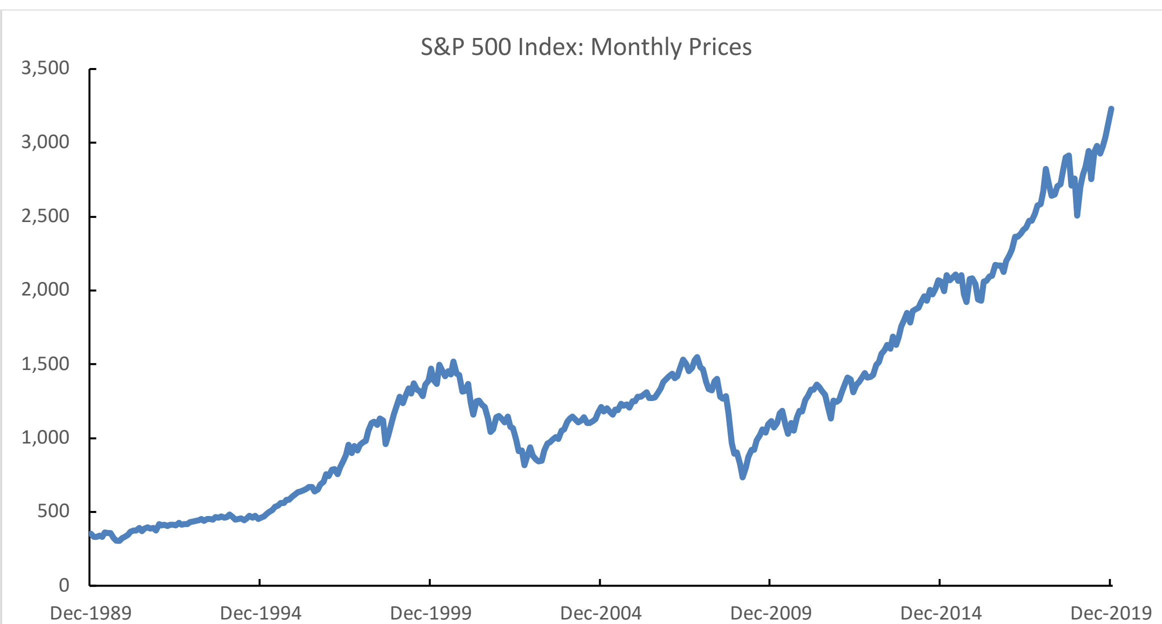

Figure 2. Monthly Prices of the Nikkei 225 Index

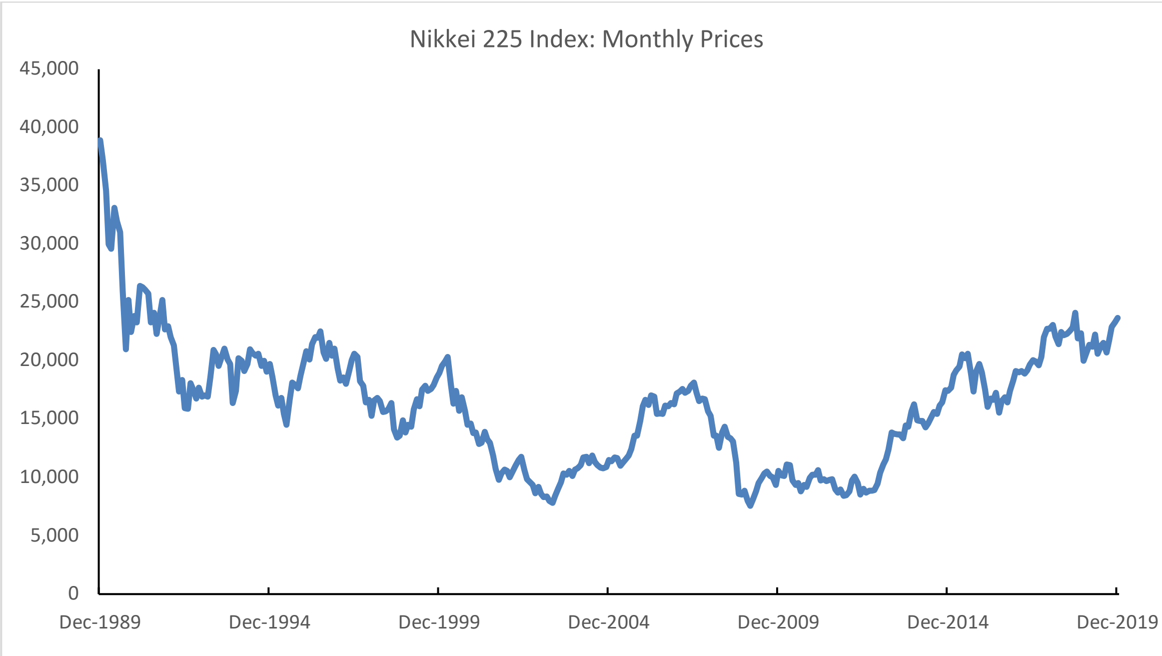

Table 1 presents summary statistics of the S&P 500 and Nikkei 225 indexes in the entire period of December 1989 to December 2019. Our first observation of Table 1 is that the average index price reported here is higher than the average cost per share reported in Table 2. For example, the average price of the S&P 500 Index is $1,267.93, while the average cost per share for purchasing the index is respectively $913.35 (DCA), $913.44 (MT1), $911.96 (MT2), $902.46 (MT3), and $812.40 (PF). Likewise, the average price of the Nikkei 225 Index is ¥16,213.88, while the average cost per share for purchasing the index is respectively ¥14,522.56 (DCA), ¥14,504.14 (MT1), ¥14,348.27 (MT2), ¥14,238.00 (MT3), and ¥11,474.90 (PF). Therefore, the average purchase cost per share tends to be cheaper than the average index price, which is the advantage of the DCA, MT, and PF methods.

Table 1. Summary Statistics of the S&P 500 and Nikkei 225 Indexes

The table presents summary statistics of the S&P 500 and Nikkei 225 indexes. Monthly data are used, ranging from December 1989 to December 2019.

	S&P 500	**Nikkei 225**
Beginning index price (December 1989)	$353.40	¥38,915.87
Ending index price (December 2019)	$3,230.78	¥23,656.62
Average index price	$1,267.93	¥16,213.88
% change in price from Dec 1989 to Dec 2019	814.20%	-39.21%
Mean of monthly returns	0.7014%	0.0469%
S.D. of monthly returns	4.0984%	6.0418%
Median of monthly returns	1.1078%	0.3691%
Maximum of monthly returns	11.1588%	20.0662%
Minimum of monthly returns	-16.9425%	-23.8269%

Our second observation of Table 1 is that over the entire period, the % change in price is 814.20% for the S&P 500 Index and -39.21% for the Nikkei 225 Index. In addition, the mean of monthly returns is 0.7014% for the S&P 500 Index and 0.0469% for the Nikkei 225 Index; and the median of monthly returns is 1.1078% for the S&P 500 Index and 0.3691% for the Nikkei 225 Index. Hence, the returns of the U.S. are much higher than those of Japan.

Our third observation of Table 1 is that the S&P 500 Index has a lower standard deviation of monthly returns (4.0984%) than the Nikkei 225 Index (6.0418%). On the one hand, the higher return and lower risk of the S&P 500 Index are in accordance with the features of a long bull market. On the other hand, the lower return and higher risk of the Nikkei 225 Index are in line with the characteristics of a long bear market.

Table 2 presents the investment outcomes of the entire period based on the DCA, MT1, MT2, MT3, and PF methods. Our first view of Table 2 is that the Total Shares Purchased, the Average Cost per Share, and the Ending Cash are necessary elements of investment activities, but they are not the measures of ultimate outcomes. As we observe, the DCA has more Total Shares Purchased than the MTs, but much fewer Total Shares Purchased than the PF. Additionally, the DCA may have a higher or lower Average Cost per Share than the MTs, but it has a much higher Average Cost per Share than the PF. Finally, the DCA has zero Ending Cash, while the others have positive amounts of Ending Cash. These observations do not allow us to determine which method is consistently better than the others.

Our second view of Table 2 is that given the same total cash contributions and monthly patterns, the Ending Value and the Net Return are the key outcome measures.[2] As the results show, the DCA may have a higher or lower Ending Value and Net Return than the MTs, but it has a much lower Ending Value and Net Return than the PF. For instance, regarding the investment in the S&P 500 Index, the Net Return is separately 253.73% (DCA), 251.82% (MT1), 243.50% (MT2), 226.81% (MT3), and 288.59% (PF). Concerning the investment in the Nikkei 225 Index, the Net Return is separately 62.90% (DCA), 62.86% (MT1), 63.64% (MT2), 61.79% (MT3), and 102.62% (PF). In summary, the PF generates much higher net returns than the DCA, while the MTs may deliver either higher or lower net returns than the DCA. Therefore, the PF certainly dominates the DCA, but the MTs do not beat the DCA consistently.

Our third view of Table 2 is that the two reference measures, the Average Monthly Return and the Modified Sharpe Ratio, support the implication from our second view. Specifically, the DCA may have a higher or lower Average Monthly Return and Modified Sharpe Ratio than the MTs, but it has a much lower Average Monthly Return and Modified Sharpe Ratio than the PF. In other words, the PF generates much higher average returns and risk-adjusted average returns than the DCA, while the MTs may deliver either higher or lower results than the DCA. Hence, there lacks evidence for the perspective of the MTs beating the DCA consistently, even though the PF tops the DCA. To further examine both the consistency and the significance, we conduct some statistical tests in the next, based on the data of month-by-month rolling periods.

[2] For example, in Panel A of Table 2, the Ending Value for the DCA investment in the S&P 500 Index is $12.734 million, calculated as $3,230.78 * 3,941.53 shares + $0 = $12,734,216, where $3,230.78 is the ending index price, 3,941.53 is the total shares purchased, and $0 is the ending cash. In addition, the Net Return is calculated as ($12.734216 million - $3.6 million) / $3.6 million = 253.73%.

Table 2. Investment Outcomes: Entire Period

The table presents the investment outcomes of the entire period, based on the dollar cost averaging (DCA), market timing (MT1, MT2, and MT3), and 12-month perfect foresight (PF) methods. Monthly data are examined, covering from January 1990 to December 2019. The total cash contributions in the entire period are 3.6 million, in the same currency of their matching equity index.

Panel A. Investment in the S&P 500 Index

	DCA	MT1	MT2	MT3	PF
Total Shares Purchased	3,941.53	3,912.02	3,780.31	3,506.89	4,295.89
Average Cost per Share	$913.35	$913.44	$911.96	$902.46	$812.40
Ending Cash	$0	$26,624	$152,512	$435,164	$110,000
Ending Value	$12.734 million	$12.665 million	$12.366 million	$11.765 million	$13.989 million
Net Return	253.73%	251.82%	243.50%	226.81%	288.59%
Average Monthly Return	0.7225%	0.7191%	0.7030%	0.6735%	0.7753%
Modified Sharpe Ratio	0.1769	0.1769	0.1771	0.1780	0.1991

Panel B. Investment in the Nikkei 225 Index

	DCA	MT1	MT2	MT3	PF
Total Shares Purchased	247.89	247.24	246.13	236.19	303.27
Average Cost per Share	¥14,522.56	¥14,504.14	¥14,348.27	¥14,238.00	¥11,474.90
Ending Cash	¥0	¥13,991	¥68,390	¥237,106	¥120,000
Ending Value	¥5.864 million	¥5.823 million	¥5.891 million	¥5.825 million	¥7.294 million
Net Return	62.90%	62.86%	63.64%	61.79%	102.62%
Average Monthly Return	0.0594%	0.0612%	0.0672%	0.0627%	0.3981%
Modified Sharpe Ratio	0.0098	0.0102	0.0114	0.0107	0.0764

III.2. Various rolling periods

Table 3 compares the investment outcomes of the DCA, MT1, MT2, MT3, and PF methods, based on the monthly data of 5-year rolling periods. The total cash contributions every 5 years are 0.6 million, in the same currency of their matching equity index. First, we examine the Net Return in Table 3. For the investment in the S&P 500 Index, the mean of rolling 5-year net returns is respectively 24.76% (DCA), 24.55% (MT1), 23.52% (MT2), 21.89% (MT3), and 42.54% (PF). In particular, the difference between the PF and the DCA is positive and significant, with a t-value of 6.88. In contrast, the differences between the MTs and the DCA are insignificant in the U.S. market.

For the investment in the Nikkei 225 Index, the mean of rolling 5-year net returns is respectively 6.23%

Table 3. Investment Outcomes: 5-Year Rolling Periods

The table compares the investment outcomes of several methods (DCA, MT1, MT2, MT3, and PF). Monthly data of 5-year rolling periods are tested. The total cash contributions in every 5 years are 0.6 million, in the same currency of their matching equity index. The star (*) represents statistical significance at the 5% level.

Panel A. Net Return

	S&P 500			Nikkei 225		
	Mean	MT-DCA PF- DCA	t-value on Difference	Mean	MT-DCA PF- DCA	t-value on Difference
DCA	24.76%			6.23%		
MT1	24.55%	-0.21%	-0.08	6.17%	-0.06%	-0.02
MT2	23.52%	-1.24%	-0.51	6.42%	0.20%	0.08
MT3	21.89%	-2.87%	-1.23	6.34%	0.12%	0.05
PF	42.54%	17.77%	6.88*	32.85%	26.62%	8.55*

Panel B. Average Monthly Return

	S&P 500			Nikkei 225		
	Mean	MT-DCA PF- DCA	t-value on Difference	Mean	MT-DCA PF- DCA	t-value on Difference
DCA	0.6854%			0.1426%		
MT1	0.6817%	-0.0037%	-0.07	0.1432%	0.0006%	0.01
MT2	0.6650%	-0.0204%	-0.37	0.1474%	0.0047%	0.07
MT3	0.6338%	-0.0516%	-0.95	0.1442%	0.0015%	0.02
PF	0.7280%	0.0426%	0.77	0.3490%	0.2064%	3.26*

Panel C. Modified Sharpe Ratio

	S&P 500			Nikkei 225		
	Mean	MT-DCA PF- DCA	t-value on Difference	Mean	MT-DCA PF- DCA	t-value on Difference
DCA	0.1985			0.0377		
MT1	0.1985	0.0000	0.00	0.0378	0.0001	0.01
MT2	0.1986	0.0001	0.01	0.0383	0.0006	0.05
MT3	0.1985	0.0000	0.00	0.0393	0.0016	0.13
PF	0.2140	0.0155	0.97	0.0738	0.0361	2.94*

(DCA), 6.17% (MT1), 6.42% (MT2), 6.34% (MT3), and 32.85% (PF). Specifically, the difference between the PF and the DCA is positive and significant, with a t-value of 8.55, while the differences between the MTs and the DCA are insignificant in the Japanese market. Therefore, when the PF absolutely outperforms the DCA, the MTs and the DCA create similar net returns. No doubt, the MTs hold neither a consistent nor a significant advantage against the DCA.

Second, we examine the reference measures in Table 3. Regarding the Average Monthly Return and the Modified Sharpe Ratio, the differences between the PF and the DCA are positive but insignificant in the U.S. market, and positive and significant in the Japanese market. However, the differences between the MTs and the DCA are insignificant, endorsing the proposition from our first examination of Table 3.

Table 4 compares the investment outcomes of various methods based on the monthly data of 10-year rolling periods. The total cash contributions every 10 years are 1.2 million, in the same

Table 4. Investment Outcomes: 10-Year Rolling Periods

The table compares the investment outcomes of several methods (DCA, MT1, MT2, MT3, and PF). Monthly data of 10-year rolling periods are tested. The total cash contributions in every 10 years are 1.2 million, in the same currency of their matching equity index. The star (*) represents statistical significance at the 5% level.

Panel A. Net Return

	S&P 500			Nikkei 225		
	Mean	MT-DCA PF- DCA	t-value on Difference	Mean	MT-DCA PF- DCA	t-value on Difference
DCA	41.34%			9.45%		
MT1	41.11%	-0.23%	-0.07	9.49%	0.04%	0.01
MT2	40.14%	-1.20%	-0.35	10.31%	0.86%	0.26
MT3	37.96%	-3.38%	-1.04	10.78%	1.33%	0.40
PF	65.60%	24.26%	6.72*	37.50%	28.05%	7.62*

Panel B. Average Monthly Return

	S&P 500			Nikkei 225		
	Mean	MT-DCA PF- DCA	t-value on Difference	Mean	MT-DCA PF- DCA	t-value on Difference
DCA	0.5822%			0.0609%		
MT1	0.5791%	-0.0032%	-0.09	0.0614%	0.0005%	0.01
MT2	0.5648%	-0.0174%	-0.53	0.0668%	0.0059%	0.17
MT3	0.5376%	-0.0446%	-1.39	0.0659%	0.0050%	0.15
PF	0.6287%	0.0465%	1.40	0.2566%	0.1957%	6.32*

Panel C. Modified Sharpe Ratio

	S&P 500			Nikkei 225		
	Mean	MT-DCA PF- DCA	t-value on Difference	Mean	MT-DCA PF- DCA	t-value on Difference
DCA	0.1390			0.0125		
MT1	0.1389	0.0000	0.00	0.0126	0.0001	0.02
MT2	0.1389	-0.0001	-0.01	0.0132	0.0008	0.13
MT3	0.1393	0.0004	0.04	0.0144	0.0020	0.32
PF	0.1545	0.0155	1.80	0.0481	0.0357	6.36*

currency of their matching equity index. First, the results of the Net Return show the same patterns as those in Table 3. Regarding the investment in the S&P 500 Index, the mean of rolling 10-year net returns is separately 41.34% (DCA), 41.11% (MT1), 40.14% (MT2), 37.96% (MT3), and 65.60% (PF). Moreover, the difference between the PF and the DCA is positive and significant, with a t-value of 6.72, while the differences between the MTs and the DCA are insignificant in the U.S. market. Concerning the investment in the Nikkei 225 Index, the mean of rolling 10-year net returns is separately 9.45% (DCA), 9.49% (MT1), 10.31% (MT2), 10.78% (MT3), and 37.50% (PF).

Furthermore, the difference between the PF and the DCA is positive and significant, with a t-value of 7.62. In contrast, the differences between the MTs and the DCA are insignificant in the Japanese market. Second, the results of the Average Monthly Return and the Modified Sharpe Ratio demonstrate the same patterns as those in Table 3. In total, the findings of Table 4 are compatible with those of Table 3.

Table 5. Investment Outcomes: 20-Year Rolling Periods

The table compares the investment outcomes of several methods (DCA, MT1, MT2, MT3, and PF). Monthly data of 20-year rolling periods are tested. The total cash contributions in every 20 years are 2.4 million, in the same currency of their matching equity index. The star (*) represents statistical significance at the 5% level.

Panel A. Net Return

	S&P 500			Nikkei 225		
	Mean	MT-DCA PF- DCA	t-value on Difference	Mean	MT-DCA PF- DCA	t-value on Difference
DCA	77.30%			22.30%		
MT1	76.94%	-0.36%	-0.18	22.31%	0.01%	0.00
MT2	75.63%	-1.67%	-0.83	23.44%	1.15%	0.31
MT3	71.52%	-5.78%	-2.87*	23.10%	0.80%	0.22
PF	106.85%	29.55%	12.55*	55.16%	32.86%	7.76*

Panel B. Average Monthly Return

	S&P 500			Nikkei 225		
	Mean	MT-DCA PF- DCA	t-value on Difference	Mean	MT-DCA PF- DCA	t-value on Difference
DCA	0.5793%			0.0594%		
MT1	0.5761%	-0.0031%	-0.41	0.0599%	0.0005%	0.03
MT2	0.5619%	-0.0173%	-2.32*	0.0653%	0.0059%	0.34
MT3	0.5350%	-0.0443%	-6.13*	0.0645%	0.0051%	0.30
PF	0.6259%	0.0466%	5.99*	0.2551%	0.1957%	13.39*

Panel C. Modified Sharpe Ratio

	S&P 500			Nikkei 225		
	Mean	MT-DCA PF- DCA	t-value on Difference	Mean	MT-DCA PF- DCA	t-value on Difference
DCA	0.1333			0.0115		
MT1	0.1333	-0.0001	-0.04	0.0116	0.0001	0.03
MT2	0.1331	-0.0002	-0.15	0.0128	0.0012	0.41
MT3	0.1339	0.0006	0.36	0.0129	0.0014	0.47
PF	0.1490	0.0156	9.12*	0.0487	0.0371	14.20*

Table 5 compares the investment outcomes of various methods based on the monthly data of 20-year rolling periods. The total cash contributions every 20 years are 2.4 million, in the same currency as their matching equity index. First, the outcomes of the Net Return reveal similar features as those in Table 3. About the investment in the S&P 500 Index, the mean of rolling 20-year net returns is respectively 77.30% (DCA), 76.94% (MT1), 75.63% (MT2), 71.52% (MT3), and 106.85% (PF). Besides, the difference between the PF and the DCA is positive and significant, with a t-value of 12.55, while the differences between the MTs and the DCA are either insignificant, or significant but negative in the U.S. market. As for the investment in the Nikkei 225 Index, the mean of rolling 20-year net returns is respectively 22.30% (DCA), 22.31% (MT1), 23.44% (MT2), 23.10% (MT3), and 55.16% (PF). In addition, the difference between the PF and the DCA is positive and significant, with a t-value of 7.76, while the differences between the MTs and the DCA are insignificant in the Japanese market. Second, the outcomes of the Average Monthly Return and the Modified Sharpe Ratio convey similar attributes as those in Table 3. Specifically, the differences between the PF and the DCA are positive and significant. However, the differences between the MTs and the DCA are insignificant or significant but negative. All told, the findings of Table 5 are congruent with those of Table 3.

IV. Conclusions

Our study investigates a few equity investment methods: the dollar cost averaging, three variations of market timing, and 12-month perfect foresight. The investment target is, respectively, the S&P 500 and Nikkei 225 indexes. The investment period is from January 1990 to December 2019. The investment methods are constructed according to the same assumptions: a series of monthly cash contributions, no equity selling allowed, no cash borrowing allowed, 0% interest rate for cash savings, etc. The dollar cost averaging method is to invest every monthly cash contribution immediately in an equity index. The three market timing methods are to invest more (less) than the monthly cash contribution, under the cash constraint, if the equity price has declined (risen). The 12-month perfect foresight method is to invest, under the cash constraint, at the lowest equity price of the current and next 12 months. To compare the outcomes of these methods, we define the net return in the entire period as the most important measure, which reflects the net gain of the ending value relative to the total cash contributions.

Our study brings forth two critical findings. First, the 12-month perfect foresight method produces consistently and significantly higher net returns than the dollar cost averaging in both the U.S. and Japanese markets. Nevertheless, the perfect foresight method is unattainable by human beings and unintended for any real-world application. It is used in this paper to identify the optimal boundaries.

Second, the market timing and the dollar cost averaging methods provide similar net returns in both the U.S. and Japanese markets. As shown by the respective 5-year, 10-year, and 20-year rolling period tests, most of the differences between the two methods (MT−DCA) are insignificant, with a few cases being significant but negative. As for the real-world application, automatic investments are usually available for the dollar cost averaging, but perhaps not for the market timing. In a consistent, significant, and practical manner, the market timing does not beat the dollar cost averaging at all. Therefore, to invest a series of monthly cash contributions in an equity index over a long time, we may prefer the dollar cost averaging to the market timing method.

Of course, when we implement an investment plan of dollar cost averaging, our decision may be affected by financial variables such as the net return and many other issues. For example, it tends to be easy to carry on a plan of dollar cost averaging in a secular bull market but difficult to stick with it in a secular bear market due to the economic recession, the pessimistic mood, and the herding behavior. Besides, equity selling, portfolio rebalancing, and cash borrowing are permitted in real-world operations, and they may be applied with the dollar cost averaging together. All these cyclical, psychological, and operational issues will complicate our investment practice, but they are beyond the scope of this paper.

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Appendix A. Examples of Invested Amounts

The appendix shows examples of invested amounts from January 1990 to December 1991, according to the MT1, MT2, MT3, and PF methods.

Panel A. Investment in the S&P 500 Index

	Price ($)	Invested Amount ($)			
	S&P 500	MT1	MT2	MT3	PF
January 1990	329.08	10,000.00	10,000.00	10,000.00	0
February 1990	331.89	9,914.61	9,914.61	9,914.61	0
March 1990	339.94	9,757.45	9,674.13	9,674.13	0
April 1990	330.80	10,268.87	9,934.24	9,934.24	0
May 1990	361.23	9,080.11	9,020.40	9,020.40	0
June 1990	358.02	10,088.86	9,100.56	9,100.56	0
July 1990	356.15	10,052.23	9,148.09	9,148.09	0
August 1990	322.56	10,837.87	10,010.88	10,010.88	0
September 1990	306.05	10,000.00	10,523.28	10,523.28	0
October 1990	304.00	10,000.00	10,593.77	10,593.77	100,000
November 1990	322.22	9,400.66	9,958.84	9,958.84	10,000
December 1990	330.22	9,751.72	9,711.59	9,711.59	10,000
January 1991	343.93	9,584.82	9,584.82	9,548.74	10,000
February 1991	367.07	9,327.19	8,939.94	8,906.29	10,000
March 1991	375.22	9,777.97	8,741.45	8,708.55	0
April 1991	375.34	9,996.80	8,738.66	8,705.76	0
May 1991	389.83	9,613.95	8,401.30	8,369.68	0
June 1991	371.16	10,478.93	8,803.66	8,770.52	40,000
July 1991	387.81	9,551.41	8,408.74	8,377.08	0
August 1991	395.43	9,803.51	8,243.51	8,212.48	0
September 1991	387.86	10,191.44	8,401.33	8,369.70	0
October 1991	392.45	9,881.66	8,301.90	8,270.65	0
November 1991	375.22	10,439.04	8,666.39	8,633.76	50,000
December 1991	417.09	8,884.12	7,699.32	7,670.34	0

(Continued)

Appendix A continued.

Panel B. Investment in the Nikkei 225 Index

	Price (¥)	Invested Amount (¥)			
	Nikkei 225	MT1	MT2	MT3	PF
January 1990	37,188.95	10,000.00	10,000.00	10,000.00	0
February 1990	34,591.99	10,000.00	10,000.00	10,000.00	0
March 1990	29,980.45	10,000.00	10,000.00	10,000.00	0
April 1990	29,584.80	10,000.00	10,000.00	10,000.00	0
May 1990	33,130.80	8,801.41	8,801.41	8,801.41	0
June 1990	31,940.24	10,359.35	9,117.69	9,117.69	0
July 1990	31,035.66	10,283.21	9,375.91	9,375.91	0
August 1990	25,978.37	10,556.03	10,903.73	10,903.73	0
September 1990	20,983.50	10,000.00	11,801.25	11,801.25	90,000
October 1990	25,194.10	7,993.38	9,433.19	9,433.19	0
November 1990	22,454.63	11,087.35	10,458.90	10,458.90	0
December 1990	23,848.71	9,379.16	9,809.57	9,809.57	0
January 1991	23,293.14	10,232.96	10,232.96	10,298.35	0
February 1991	26,409.22	8,662.23	8,864.02	8,920.67	0
March 1991	26,292.04	10,044.37	8,903.36	8,960.25	0
April 1991	26,111.25	10,068.76	8,964.58	9,021.86	0
May 1991	25,789.62	10,123.18	9,075.00	9,132.99	0
June 1991	23,290.96	10,968.86	9,954.24	10,017.85	0
July 1991	24,120.75	9,643.73	9,599.60	9,660.95	0
August 1991	22,335.87	10,739.98	10,309.95	10,375.83	0
September 1991	23,916.44	9,292.36	9,580.38	9,641.60	0
October 1991	25,222.28	9,454.00	9,057.29	9,115.17	0
November 1991	22,687.35	11,005.04	9,967.58	10,031.28	0
December 1991	22,983.77	9,869.35	9,837.35	9,900.21	0