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# Building a Better Mousetrap: Enhanced Dollar Cost Averaging

Lee Dunham
*Creighton University, Omaha, NE*, leedunham@creighton.edu

Geoffrey C. Friesen
*University of Nebraska-Lincoln*, gfriesen2@unl.edu

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Lee M. Dunham
Assistant Professor of Finance
Creighton University
2500 California Plaza
Omaha, NE 68118
leedunham@creighton.edu
(402) 280-2637

Geoffrey C. Friesen
Associate Professor of Finance
University of Nebraska-Lincoln
College of Business Administration
Lincoln, NE 68588-0490
gfriesen2@unl.edu
(402) 472-2334

**ABSTRACT**

This paper presents a simple, intuitive investment strategy that improves upon the popular dollar-cost-averaging (DCA) approach. The investment strategy, which we call enhanced dollar-cost-averaging (EDCA), is a simple, rule-based strategy that retains most of the attributes of traditional DCA that are appealing to most investors but yet adjusts to new information, which traditional DCA does not. Simulation results show that the EDCA strategy reliably outperforms the DCA strategy in terms of higher dollar-weighted returns about 90% of the time and nearly always delivers greater terminal wealth for reasonable values of the risk premium. EDCA is most effective when applied to high volatility assets, when cash flows are highly sensitive to past returns, and during secular bear markets. Historical back-testing on equity indexes and mutual funds indicates that investor dollar-weighted returns can be enhanced by between 30 and 70 basis points per year simply by switching from DCA to EDCA.

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This paper presents a simple, intuitive investment strategy that improves upon the popular dollar-cost-averaging (DCA) approach. The investment strategy, which we call enhanced dollar-cost-averaging (EDCA), is a simple, rule-based strategy that retains most of the attributes of traditional DCA that are appealing to most investors but yet adjusts to new information, which traditional DCA does not. Simulation results show that the EDCA strategy reliably outperforms the DCA strategy in terms of higher dollar-weighted returns about 90% of the time and nearly always delivers greater terminal wealth for reasonable values of the risk premium. EDCA is most effective when applied to high volatility assets, when cash flows are highly sensitive to past returns, and during secular bear markets. Historical back-testing on equity indexes and mutual funds indicates that investor dollar-weighted returns can be enhanced by between 30 and 70 basis points per year simply by switching from DCA to EDCA.

There is an old saying on Wall Street that "bulls make money, bears make money, and pigs get slaughtered." The average investor, chasing past performance, typically gets slaughtered (Ippolito, 1992; Friesen and Sapp, 2007). Dollar-cost averaging is often recommended as a way to counter investors' tendencies to buy and sell at the wrong time. In this paper, we present a simple, intuitive investment strategy that improves upon the popular dollar-cost-averaging (DCA). Our strategy is particularly well-suited for investors making regular contributions to investment portfolios.[1]

Dollar-cost-averaging is used to invest lump sums, and also by investors making periodic investments. Constantinides (1979) shows that in a rational expectations framework, the use of dollar-cost-averaging as a vehicle for investing a lump sum is suboptimal. The optimal strategy simply allocates the entire lump sum to the optimal portfolio. Not only is dollar-cost-averaging dominated by the optimal strategy, but it can also be shown that there exists a sequential (i.e. gradual) strategy which dominates dollar-cost-averaging. Unlike dollar-cost-averaging, which never alters the planned investment in the face of new information, the optimal sequential strategy incorporates information that becomes available over time. Samuelson (1994) suggests that for fiduciary trustees, use of sub-optimal dollar-cost-averaging is a blunder if not a criminal act.

While dollar-cost-averaging may be suboptimal for a rational investor, Statman (1995) offers three behavioral rationales for its use. First, a mathematical property of dollar-cost-averaging is that over any arbitrary investment period, the average price paid is always less than

[1] The EDCA strategy involves systematic adjustments to cash flows based on past returns and therefore can be most directly applied to portfolios where the owner or portfolio manager has discretion over the size of the periodic cash flows. EDCA can also benefit investors in Defined Contribution (DC) plans, although plan participants generally do not have the option of easily increasing or decreasing their contributions on a monthly basis. Some specific examples of DC plans include contract-based plans in the U.K., registered retirement savings plans (RRSPs) and tax-free retirement savings plans (TFRSPs) in Canada, and 401(k), 403(b) and Roth IRAs in the U.S. The practical implementation in such plans would require coordination between portfolio managers, systems personnel, and likely the compliance and legal departments of the plan administrator. In theory, a plan custodian might offer EDCA as an alternative to traditional dollar-cost-averaging, which would require the plan administrator to have a computer system that could accommodate such an option. One practical way of doing this would be to have a fixed monthly contribution automatically placed into a money market account, then to apply the EDCA methodology to control the dollar amount of assets swept out of the money market account every week/month. The purpose of this paper is not to address specific institutional details required to implement the EDCA strategy, but rather to demonstrate the economic advantages of doing so.

the average price. Though this property is unrelated to the issue of optimality, it makes dollar-cost-averaging a compelling strategy for many investors, given the way they frame sequential decisions. Second, it is well-established that the pain of regret exceeds the joy of pride for most humans. A 30% decline in stocks causes much more pain than a 30% increase causes joy, and if the pain of regret is sufficiently acute, it may prevent some investors from ever investing in stocks. Kahneman and Tversky (1982) note a positive correlation between regret and the level of responsibility for a choice. Following a rule such as dollar-cost-averaging reduces most investors' sense of personal responsibility, which reduces the level of regret for bad outcomes and enables them to invest in riskier assets. Third, rules such as dollar-cost-averaging serve to combat lapses in self control that may cause investors to abandon their investment plans at the worst possible time. Thus, dollar-cost-averaging may be inferior to the optimal strategy, but is superior to the strategy most investors are likely to adopt as a result of their human nature.

At one level, the Constantinides (1979) and Samuelson (1994) criticisms of dollar-cost-averaging do not apply to periodic investments such as defined contribution plans, which by their very nature require sequential investments. But the criticisms do apply to sequential investment strategies in the following sense: dollar-cost-averaging ignores new information, and thus will generally be inferior to the optimal sequential investment strategy. The purpose of this paper is to present a practical investment strategy that more closely resembles the optimal sequential strategy, yet retains the attributes of dollar-cost-averaging that are appealing to behavioral investors. Our simple, intuitive rule-based strategy "removes personal responsibility" and the sense of regret that such heightened responsibility causes investors in down markets. To improve upon DCA, our strategy takes account of new information, which DCA does not. Our rule does so in the simplest possible way by recognizing that, all else equal, a positive return makes stocks more expensive, and a negative return makes them cheaper.

To anticipate our results, we present a simple example in Exhibit 1 that illustrates the effect of such a strategy on an investor's average return and terminal wealth. Consider two investors investing over thirty years in the same underlying asset. The asset earns a -10% annual return in year 1 and +10% annual returns thereafter. Investor 1 invests \$100 at the beginning of years 1 and 2. Investor 2 invests \$0 at the beginning of year 1 and \$200 at the beginning of year 2. Of course, by investing more after the negative return in year 1, Investor 2 will earn a higher average return and have a higher terminal wealth than Investor 1. Exhibit 1 reports the accumulated balance for both investors, as well as each investor's dollar-weighted-average return. The numbers in Exhibit 1 illustrate several points: First, by investing more after the negative return in year 1, Investor 2 earns a higher average return and has greater terminal wealth than Investor 1. Second, the size of the wealth difference grows with the investment horizon (e.g. Investor 2 is ahead by only $12.10 after year 3, but is ahead by $158.63 after year 30). Lastly, the difference in the average annual return actually declines with the investment horizon (the difference in average returns is 4.3% per year after 3 years, but only 0.4% per year after 30 years).

Our investment strategy, which we call enhanced dollar-cost-averaging (EDCA), follows traditional DCA very closely but allows for a slight change to take advantage of new information. The EDCA strategy invests a fixed additional amount after a down month, and reduces the investment by a fixed amount after an up month. Specifically, it invests an additional $Y in month *t+1* if the return in month *t* is negative, and invest $Y less in month *t+1* if the return in month *t* is positive. We also present results for an enhanced EDCA model that adjusts the additional or reduction in the monthly contribution conditional upon the size of the lagged monthly return.

Our main results can be summarized as follows. We compare the return performance of our EDCA strategy with that of traditional DCA and document that our EDCA strategy reliably outperforms the DCA strategy. The EDCA strategy nearly always delivers higher dollar-weighted returns, and delivers greater terminal wealth up to 95% of the time. Furthermore, our results are generally robust to various measures of the risk premium and asset volatility although EDCA performs better for assets with greater volatility.

## Enhanced DCA Strategy vs. Traditional DCA Strategy

This section simulates random return data to analyze the return differences between dollar-cost-averaging (DCA) and our enhanced dollar-cost-averaging (EDCA) strategy. Using random return data enables us to isolate the impact of different investment strategies on investor returns, knowing that the differences are driven by the different strategies, and not any underlying patterns of predictability in the data.

**Exhibit 1**
**Wealth and Return Differences: DCA vs. Market Timing**

| | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 10 | Year 30 |
|---|---|---|---|---|---|---|---|
| ***Return on Asset :*** | -10% | 10% | 10% | 10% | 10% | 10% | 10% |
| ***Investor 1 Cash flow (BOY)*** | $100.00 | $100.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 |
| Account Balance (EOY): | $90.00 | $209.00 | $229.90 | $252.89 | $278.18 | $448.01 | $3,013.99 |
| Annual Dollar-weighted Return: | -10.0% | 3.0% | 5.7% | 6.9% | 7.6% | 8.8% | 9.6% |
| ***Investor 2 Cash flow (BOY)*** | $0.00 | $200.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 |
| Account Balance (EOY): | $0.00 | $220.00 | $242.00 | $266.20 | $292.82 | $471.59 | $3,172.62 |
| Annual Dollar-weighted Return: | 0.0% | 10.0% | 10.0% | 10.0% | 10.0% | 10.0% | 10.0% |
| ***Difference in Average Return*** | | 7.0% | 4.3% | 3.1% | 2.4% | 1.2% | 0.4% |
| ***Difference in Ending Wealth*** | | $11.00 | $12.10 | $13.31 | $14.64 | $23.58 | $158.63 |

The benchmark strategy in this section is a DCA strategy that invests $X per month for N years. Prices are assumed to follow a random walk with drift $P_{t+1} = P_t + \mu + \epsilon$, and monthly returns are independent and identically distributed normal random variables with mean μ and standard deviation σ. For each simulation, we generate 10,000 time-series of returns. Unless otherwise stated, monthly returns have an annualized mean of 6% and annualized standard deviation of 25%. We consider investment horizons of N = 2, 5, 10 and 30 years.

To illustrate our results, we compare the performance of a traditional DCA strategy with our EDCA strategy. The first EDCA strategy we examine is a basic strategy that invests an additional fixed amount after a down month, and reduces the investment by a fixed amount after an up month. Specifically, it invests an additional $Y in month t+1 if the return in month t is negative, and invest $Y less in month t+1 if the return in month t is positive. In Exhibit 2, we compare the returns and terminal wealth differences of the DCA investor to the EDCA investor. We consider time periods of N=2, 5, 10 and 30 years; and additional investments $Y equal to 10%, 50% and 100% of the benchmark DCA contribution.[2]

The base monthly contribution for the DCA strategy is $X=$100. For an EDCA strategy with a value of Y=10%, contributions are increased by 10% (to $110) when the past month's return is negative, and decreased by 10% (to $90) when the past month's return is positive. The DCA contributions are constant each month regardless of return performance. To facilitate comparisons of both the returns as well as the terminal wealth of the investment, we constrain the sum of the total contributions in the DCA strategy for a particular simulation path to be equal to the sum of the total contributions in the EDCA strategy in that same simulation path. We do this by setting the DCA contribution equal to the average EDCA contribution in each simulation path. In this way, we can directly compare the terminal wealth of each investment, knowing that the total dollar contributions are always equal in every simulation.

Exhibit 2 reports the EDCA return enhancement, calculated as the average dollar-weighted return under the EDCA strategy minus the average dollar-weighted return under the DCA strategy. Using the dollar-weighted return for each strategy, while keeping the return of

[2] It is likely that the portfolio allocations for investors with shorter investment horizons will be more conservative relative to investors with longer horizons. As a result, investors with short horizons may have portfolios tilted toward low-volatility assets and will likely benefit less from the EDCA strategy. We have used the short horizons primarily to highlight the properties of the EDCA strategy when applied over different horizons, so that practitioners might understand how the properties depend upon both the investment horizon and volatility of the underlying portfolio.

the actual underlying investment the same for both strategies, allows us to isolate the impact of timing differences in cash flows on investors' actual dollar-weighted returns. Data in Exhibit 2 indicate that the EDCA strategy generates higher average returns than the DCA strategy over 85% of the time, and this percentage does not depend upon the sensitivity of cash flows to past returns. The size of the return enhancement does increase with the adjustment factor $Y, implying that investors gain greater return enhancement when cash flows are more sensitive to the past month's return. This can be seen by comparing the average return enhancement across panels (a) through (c) for a given investment horizon. Exhibit 2 also shows that over a two-year period, terminal wealth is higher for the EDCA strategy over 60% of the time, and the size of the terminal wealth difference increases with the adjustment factor $Y. For holding periods of five years, terminal wealth is higher under the EDCA strategy 85% of the time; for holding periods of thirty years, the percentage increases to nearly 90%. Also, the average monthly return enhancement is inversely related to the investment horizon. For example, in Panel (c), the average return enhancement is 17 basis points per year over a two-year period, but only 1 basis point over a thirty-year period.[3]

### EDCA Strategy and Volatility of Underlying Asset

We now examine how the performance of the basic EDCA strategy varies with volatility in the underlying asset. Exhibit 3 uses the Y=100% adjustment strategy reported in the bottom panel in Exhibit 3, and sets the annualized volatility of the underlying asset to $\sigma$=10%, $\sigma$=25% and $\sigma$=40%. Recall that the strategy associated with Y=100% doubles the contribution when the past return is negative, and makes no contribution in months following a positive return. From Exhibit 3, we see that the EDCA strategy outperforms DCA on a dollar-weighted return basis between 86% and 90% of the time. As before, the probability of outperforming DCA generally

[3] Many investors who deposit a fixed percentage of their weekly, bi-weekly or monthly paycheck into a retirement savings account might like to use the EDCA strategy. To determine whether our monthly simulation results generalize to a weekly or bi-weekly setting, we have re-run the simulations calibrated to weekly and bi-weekly frequencies. The higher frequency deposits do not change the results, with the exception that the weekly return enhancement is approximately one-fourth the magnitude of the monthly return enhancement; and the bi-weekly return enhancement is approximately one-half the magnitude of the monthly return enhancement. However, once the numbers are annualized, the results do not depend significantly upon the deposit frequency.

**Exhibit 2**
**Performance Gap: Basic EDCA vs. DCA**

*Panel (a): EDCA amount Y=10%*

| Horizon: | 2 years | 5 years | 10 years | 30 years |
|---|---|---|---|---|
| DCA Return | 0.25% | 0.26% | 0.26% | 0.28% |
| EDCA Return | 0.27% | 0.27% | 0.26% | 0.28% |
| Return Enhancement | 0.02% | 0.01% | 0.00% | 0.00% |
| Prob. Return Enhancement > 0 (EDCA – DCA) | 85.95% | 86.53% | 87.40% | 89.07% |
| Terminal Wealth Diff | $6.99 | $20.58 | $51.10 | $363.88 |
| Prob Terminal Wealth Diff > 0 | 61.85% | 85.07% | 88.92% | 89.77% |

*Panel (b): EDCA amount Y=50%*

| Horizon: | 2 years | 5 years | 10 years | 30 years |
|---|---|---|---|---|
| DCA Return | 0.25% | 0.26% | 0.26% | 0.28% |
| EDCA Return | 0.33% | 0.29% | 0.28% | 0.29% |
| Return Enhancement | 0.08% | 0.03% | 0.02% | 0.01% |
| Prob. Return Enhancement > 0 (EDCA – DCA) | 85.97% | 86.53% | 87.40% | 89.07% |
| Terminal Wealth Diff | $34.96 | $102.88 | $255.48 | $1,819.42 |
| Prob Terminal Wealth Diff > 0 | 61.85% | 85.07% | 88.92% | 89.77% |

*Panel (c): EDCA amount Y=100%*

| Horizon: | 2 years | 5 years | 10 years | 30 years |
|---|---|---|---|---|
| DCA Return | 0.25% | 0.26% | 0.26% | 0.28% |
| EDCA Return | 0.42% | 0.33% | 0.29% | 0.29% |
| Return Enhancement | 0.17% | 0.07% | 0.03% | 0.01% |
| Prob. Return Enhancement > 0 (EDCA – DCA) | 86.09% | 86.53% | 87.40% | 89.06% |
| Terminal Wealth Diff | $69.92 | $205.76 | $510.96 | $3638.83 |
| Prob Terminal Wealth Diff > 0 | 61.85% | 85.07% | 88.92% | 89.77% |

**Exhibit 3**
**Impact of Asset Volatility on EDCA Return Enhancement**

*Panel (a): σ=10%*

| Horizon: | 2 years | 5 years | 10 years | 30 years |
|---|---|---|---|---|
| DCA Return | 0.46% | 0.46% | 0.46% | 0.46% |
| EDCA Return | 0.53% | 0.49% | 0.47% | 0.46% |
| Return Enhancement | 0.07% | 0.03% | 0.01% | 0.004% |
| Prob. Return Enhancement > 0 (EDCA – DCA) | 86.15% | 86.64% | 87.16% | 87.73% |
| Terminal Wealth Diff | $27.64 | $80.19 | $201.83 | $1,462.54 |
| Prob Terminal Wealth Diff > 0 | 56.22% | 64.66% | 75.18% | 70.54% |

*Panel (b): σ=25%*

| Horizon: | 2 years | 5 years | 10 years | 30 years |
|---|---|---|---|---|
| DCA Return | 0.25% | 0.26% | 0.26% | 0.28% |
| EDCA Return | 0.42% | 0.33% | 0.29% | 0.29% |
| Return Enhancement | 0.17% | 0.07% | 0.03% | 0.01% |
| Prob. Return Enhancement > 0 (EDCA – DCA) | 86.09% | 86.53% | 87.40% | 89.06% |
| Terminal Wealth Diff | $69.92 | $205.76 | $510.96 | $3638.83 |
| Prob Terminal Wealth Diff > 0 | 61.85% | 85.07% | 88.92% | 89.77% |

*Panel (c): σ=40%*

| Horizon: | 2 years | 5 years | 10 years | 30 years |
|---|---|---|---|---|
| DCA Return | -0.06% | -0.11% | -0.09% | -0.05% |
| EDCA Return | 0.27% | 0.00% | -0.03% | -0.03% |
| Return Enhancement | 0.33% | 0.11% | 0.06% | 0.02% |
| Prob. Return Enhancement > 0 (EDCA – DCA) | 87.36% | 86.55% | 88.05% | 89.74% |
| Terminal Wealth Diff | $112.67 | $329.25 | $814.46 | $5,727.99 |
| Prob Terminal Wealth Diff > 0 | 75.72% | 88.44% | 90.43% | 91.24% |

increases with the investment horizon. In addition, the results in Exhibit 3 show that the average wealth difference and the probability that the terminal wealth difference is positive and generally increases with asset volatility. The relationship between return enhancement and volatility are summarized by the empirical histogram for wealth differences in Exhibit 4. The histograms correspond to annualized volatility levels of σ=10%, σ=25% and σ=40%. The three figures in Exhibit 4 illustrate that the mean wealth difference is positive and that the probability that the EDCA strategy outperforms the traditional DCA strategy generally increases with asset volatility. The results indicate that the EDCA strategy is most beneficial when applied to assets with high return volatility.[4]

## EDCA Strategy and Sensitivity to Magnitude of Past Returns

If returns can be enhanced by investing only after negative returns, then it may be possible to further enhance returns by conditioning upon both the sign and magnitude of the previous return. We now examine another EDCA strategy in which the monthly invested amount is adjusted by a fixed percentage, *A,* of the lagged return rather by a fixed dollar amount $Y as was the case in Exhibits 2 and 3. We define *A* such that the additional contribution in month *t* is equal to *A* times the previous monthly return $r_{t-1}$. We consider adjustment factors A=-1, -5, -10 and -20. For example, if A=-10, then the investment after a -10% return is increased by -10 * (-10%) = +100% of the benchmark amount, while the investment after a +5% return is decreased by -10 * (5%) = -50%.

Exhibit 5 shows that when invested cash flows are sensitive to the magnitude of the past return, EDCA outperforms DCA on a return basis over 90% of the time, and this percentage does not seem to depend on *A,* the sensitivity of cash flows to past returns. However, the average magnitude of the return enhancement is increasing in *A,* suggesting that the largest return enhancement will result from a strategy with cash flows that are highly sensitive to past returns.

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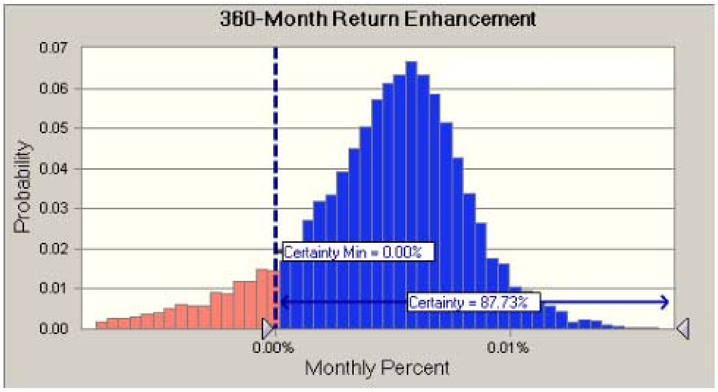
[4] The simulated data in Exhibit 2 are calibrated with an annual arithmetic mean of 6% and standard deviation of 25%. The geometric average return is equal to the arithmetic mean minus $(1/2)\sigma^2$, which in Exhibit 2 equates to 2.88% annually, or 0.24% monthly. In Exhibit 3, the annualized arithmetic mean is fixed at 6%, while the annualized volatility varies from 10% (panel a) to 40% monthly (panel c). For the distribution represented in panel (c), the geometric average equals $0.06 – ½ (0.40)^2= –0.02$, or -0.167% monthly. The purpose of using an extremely high volatility is not to illustrate the mathematical relationship between arithmetic and geometric returns, but to illustrate that the EDCA return enhancement increases with volatility.

**Exhibit 4**
**Effect of Asset Price Volatility on EDCA Return Enhancement**

*Panel (a): σ=10%*




*Panel (b): σ=25%*


*Panel (c): σ=40%*

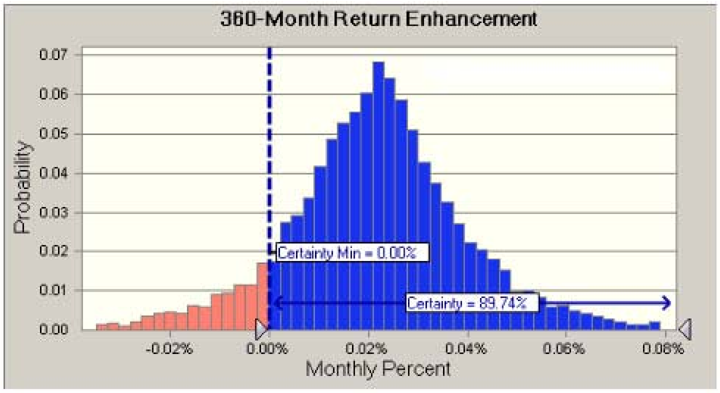


**Exhibit 5**
**Performance Gap: Conditional EDCA vs. DCA**

*Panel (a): A=-10*

| Horizon: | 2 years | 5 years | 10 years | 30 years |
|---|---|---|---|---|
| DCA Return | 0.25% | 0.26% | 0.26% | 0.28% |
| EDCA Return | 0.39% | 0.32% | 0.29% | 0.29% |
| Return Enhancement | 0.14% | 0.06% | 0.03% | 0.01% |
| Prob. Return Enhancement > 0 (EDCA – DCA) | 90.76% | 91.26% | 92.16% | 94.63% |
| Terminal Wealth Diff | $63.28 | $185.99 | $461.77 | $3,309.52 |
| Prob Terminal Wealth Diff > 0 | 77.02% | 91.54% | 94.11% | 94.38% |

*Panel (b): A=-20*

| Horizon: | 2 years | 5 years | 10 years | 30 years |
|---|---|---|---|---|
| DCA Return | 0.25% | 0.26% | 0.26% | 0.28% |
| EDCA Return | 0.53% | 0.37% | 0.32% | 0.30% |
| Return Enhancement | 0.28% | 0.11% | 0.01% | 0.02% |
| Prob. Return Enhancement > 0 (EDCA – DCA) | 91.54% | 91.71% | 92.33% | 94.57% |
| Terminal Wealth Diff | $129.83 | $379.18 | $940.64 | $6,757.77 |
| Prob Terminal Wealth Diff > 0 | 77.54% | 92.24% | 94.73% | 94.87% |

*Panel (c): A=-30*

| Horizon: | 2 years | 5 years | 10 years | 30 years |
|---|---|---|---|---|
| DCA Return | 0.25% | 0.26% | 0.26% | 0.28% |
| EDCA Return | 0.68% | 0.43% | 0.34% | 0.31% |
| Return Enhancement | 0.42% | 0.17% | 0.08% | 0.03% |
| Prob. Return Enhancement > 0 (EDCA – DCA) | 91.48% | 92.04% | 92.42% | 94.45% |
| Terminal Wealth Diff | $197.65 | $579.50 | $1,439.63 | $10,366.16 |
| Prob Terminal Wealth Diff > 0 | 77.95% | 92.93% | 95.63% | 95.53% |

Exhibit 6 presents a histogram of the conditional EDCA return enhancement for various levels of A. The mean performance gap is positive, and the probability that the EDCA outperforms the DCA increases with A. For two-year investment horizons, the EDCA strategy produces higher terminal wealth over 77% of the time, and the difference in terminal wealth increases in *A*. For holding periods of five years, terminal wealth for EDCA is higher around 92% of the time, and for periods of thirty years this increases to about 95%. Overall, results in Exhibit 5 and Exhibit 6 suggest that conditioning the amount invested each month on the size of the lagged return further enhances returns and terminal wealth from using the EDCA strategy.[5]

**Back-testing EDCA with Historical Market Index Returns**

In this section, we apply the EDCA methodology to historical return data for several market indices and a sample of U.S. open-end mutual funds. We begin by back-testing the methodology using historical return data from a diverse number of market indices. We collect historical monthly return data for the period January 2000–December 2009 from Bloomberg on the following six indices: S&P 500 Index, Dow Jones Industrial Average, Nasdaq Composite Index, Goldman Sachs Commodity Index, MSCI EAFE Index, and the Merrill Lynch Corporate Bond U.S. Master Index.[6] We chose a broad array of indices to investigate whether the EDCA methodology performance varies across asset classes.

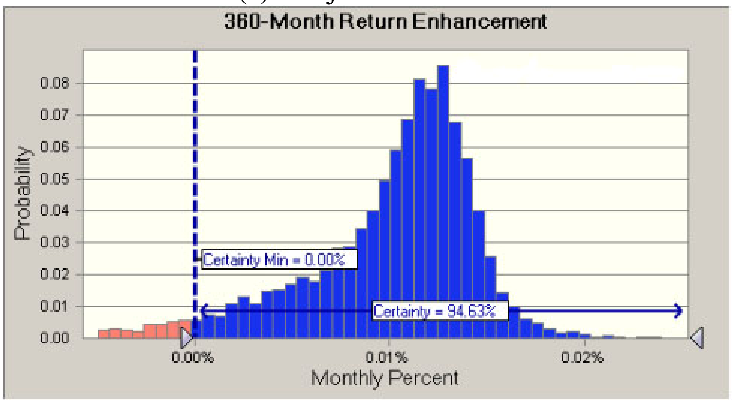
Exhibit 7 presents return performance for the six indices. For each market index, we calculate the geometric average return, and the dollar-weighted returns for the DCA and EDCA strategies. Three EDCA strategies are examined, with varying degrees of sensitivity to past returns (we utilize A= -10, -20 and -30 as defined earlier). The EDCA results suggest that the EDCA methodology leads to a positive performance enhancement over traditional DCA for all indices except the Merrill Lynch corporate bond index. On average, for the EDCA strategy

[5] It is important to note that the simulation results in no way depend upon the assumption that the mean return is positive. We have run the simulation with 0% and -6% annualized mean returns, and the key statistics of interest (e.g. the return enhancement) are essentially unchanged. In addition, we find significant return enhancements when the EDCA strategy is applied to actual return data (Section IV), which exhibits skewness and excess kurtosis relative to a normal distribution. This suggests that the symmetry of the normal distribution used in the simulations is also not driving our primary findings.

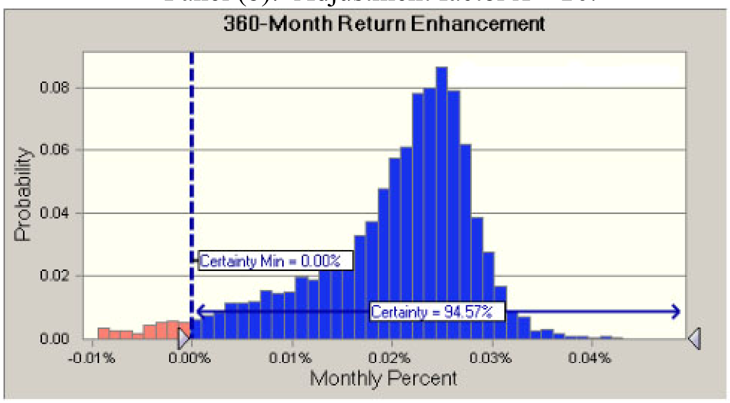
[6] We also apply the EDCA methodology to earlier data dating back to 1980 for the S&P 500 Index and Dow Jones Industrial Average and get similar results.

**Exhibit 6**
**Return Enhancement When Cash Flows are Sensitive to Sign and Magnitude of Past Return**

Panel (a): Adjustment factor *A*=*-10*.




Panel (b): Adjustment factor *A*=*-20*.




Panel (c): Adjustment factor *A*=*-30*.

where A=-10, the performance enhancement ranges from approximately 19 basis points for the S&P 500 index and the MSCI EAFE Index to 39 basis points for the Nasdaq Composite Index. For the Merrill Lynch corporate bond index, the EDCA methodology shows a very minor 3-11 basis point reduction in return performance. However, for the five indices where the performance enhancement is positive, the size of the enhancement is increasing in the level of the EDCA adjustment, which is consistent with the simulation results in Exhibit 5. In the case when A=-30, the return enhancement from using the EDCA strategy ranges from 50 to 110 basis points across the five indices.

### Back-testing EDCA with Historical Mutual Fund Returns

We also apply the EDCA methodology to the 100 largest mutual funds on the CRSP Mutual Fund Database using total net assets reported on December 31, 2009. Similar to the market index data, we use ten years of monthly return data from January 1, 2000 through December 31, 2009. Forty-eight funds are classified as equity funds, forty-nine as taxable fixed income, and three are money market funds.

For each fund, we calculate the geometric average return, and the dollar-weighted returns for the DCA and EDCA strategies. Again, three EDCA strategies are examined, with varying degrees of sensitivity to past returns (A= -10, -20 and -30). The results are presented in Exhibit 8. The EDCA strategy has an average return enhancement that is positive for all asset classes. However, the magnitude is economically meaningful only for equities, where the average annualized enhancement ranges from 17 to 70 basis points, depending on the sensitivity of cash flows to past returns. Nearly all of the equity funds (47 of 48) have a positive return enhancement over the sample period. For fixed income funds, the average return enhancement is only about 2 basis points per year and is barely statistically significant. Only 12 of the 49 fixed income funds have positive point estimates for the return enhancement. For money market funds there is no benefit from utilizing an EDCA strategy. These back-testing results are consistent

**Exhibit 7**
**Performance Gap: Conditional EDCA vs. DCA**
**Market Index Returns**

| | S&P 500 | DOW 30 | NASDAQ | GSCI | MSCI EAFE | ML Bond |
|---|---|---|---|---|---|---|
| Geometric | -0.95% | 1.30% | -5.21% | 4.94% | 1.57% | 6.38% |
| DCA | 1.35% | 2.86% | 2.85% | -0.15% | 5.29% | 6.07% |
| EDCA (A=-10) | 1.54% | 3.06% | 3.24% | 0.12% | 5.48% | 6.04% |
| EDCA (A=-20) | 1.73% | 3.26% | 3.59% | 0.48% | 5.68% | 6.00% |
| EDCA (A=-30) | 1.92% | 3.47% | 3.92% | 0.97% | 5.87% | 5.96% |
| **Enhancement (A=-10)** | **0.19%** | **0.20%** | **0.39%** | **0.28%** | **0.19%** | **-0.03%** |
| **Enhancement (A=-20)** | **0.38%** | **0.40%** | **0.74%** | **0.64%** | **0.39%** | **-0.07%** |
| **Enhancement (A=-30)** | **0.57%** | **0.61%** | **1.07%** | **1.12%** | **0.58%** | **-0.11%** |

**Exhibit 8**
**Performance Gap: Conditional EDCA vs. DCA**
**100 Largest Mutual Funds**

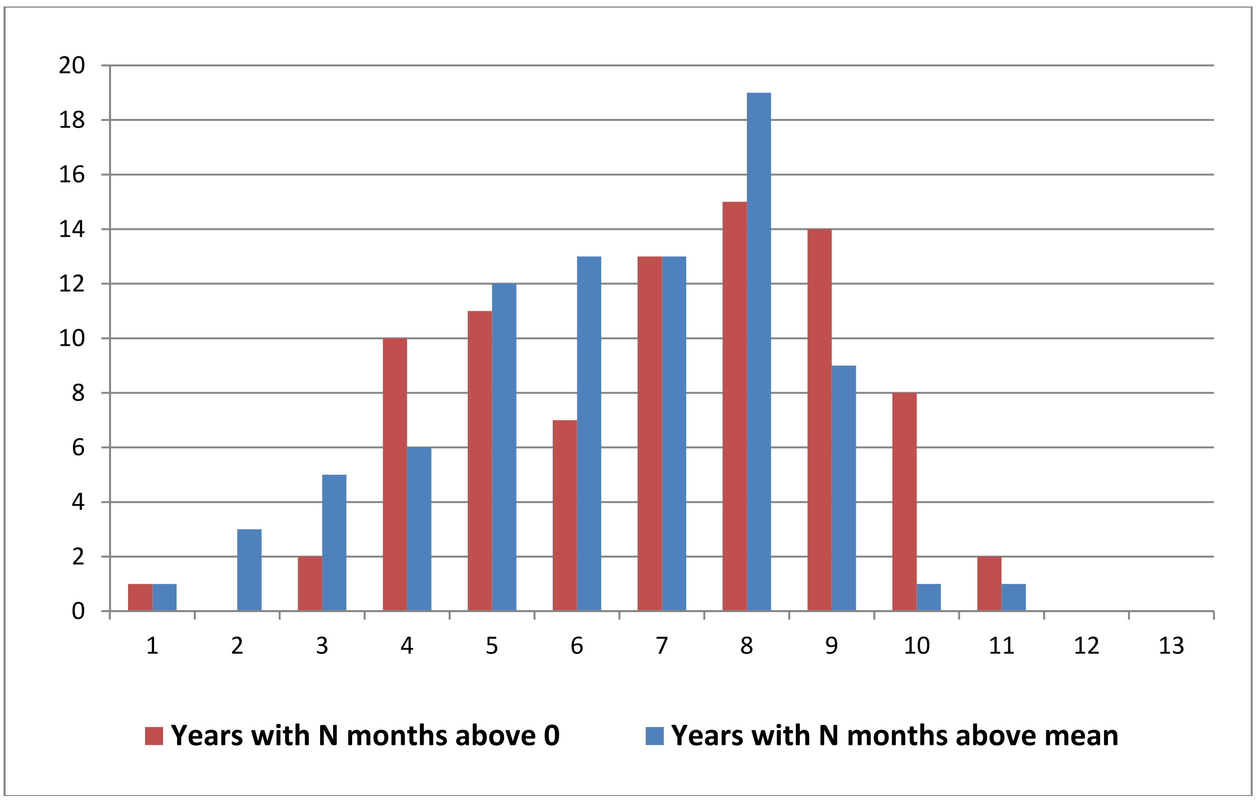
| | **Equities** | **Fixed Income** | **Money Market** |
|---|---|---|---|
| Geometric | 2.66% | 3.20% | 2.76% |
| | (4.78) | (13.51) | (3.49) |
| DCA | 3.07% | 2.83% | 2.60% |
| | (8.15) | (11.86) | (3.51) |
| EDCA (A=-10) | 3.25% | 2.85% | 2.60% |
| | (8.70) | (11.93) | (3.50) |
| EDCA (A=-20) | 3.57% | 2.84% | 2.61% |
| | (10.14) | (11.79) | (3.48) |
| EDCA (A=-30) | 3.77% | 2.84% | 2.61% |
| | (10.57) | (11.79) | (3.45) |
| **Enhancement (A=-10)** | **0.17%** | **0.02%** | **0.00%** |
| | (12.49) | (2.30) | (0.81) |
| **Enhancement (A=-20)** | **0.50%** | **0.01%** | **0.01%** |
| | (4.53) | (1.75) | (0.81) |
| **Enhancement (A=-30)** | **0.70%** | **0.01%** | **0.01%** |
| | (6.21) | (1.98) | (0.81) |
| Number of funds | 48 | 49 | 3 |
| No. where EDCA>DCA | 47 | 12 | 2 |
| Min. Enhancement (A=-30) | -0.14% | -0.02% | -0.0001% |
| Maximum Enhancement (A=-30) | 4.86% | 0.17% | 0.0416% |

with those in Exhibit 3, which demonstrated that the enhanced EDCA strategy is most beneficial when applied to high volatility assets.

## Is EDCA a Reasonable Strategy?

The EDCA strategy is a simple strategy where the contribution level is increased after a negative return month and decreased after a positive return month. One implication for investors following an EDCA strategy is that it requires investors to temporarily underinvest or even ‘sit out’ after a month with a positive return. Of possible concern is that by foregoing investments when the market is up, an investor might simply sit out an entire bull market run. Historical data suggest that there is little danger of this.  To take a closer look, we investigate the frequency of positive return months and months with above-average returns using historical monthly total returns for the S&P 500 index. Exhibit 9 shows the number of years between 1926 and 2008 with "N" positive monthly returns (red) or "N" returns above the mean (blue).  Because equities have historically earned positive returns, an alternative EDCA strategy might condition the amount contributed each month on whether the past return was above or below the mean.

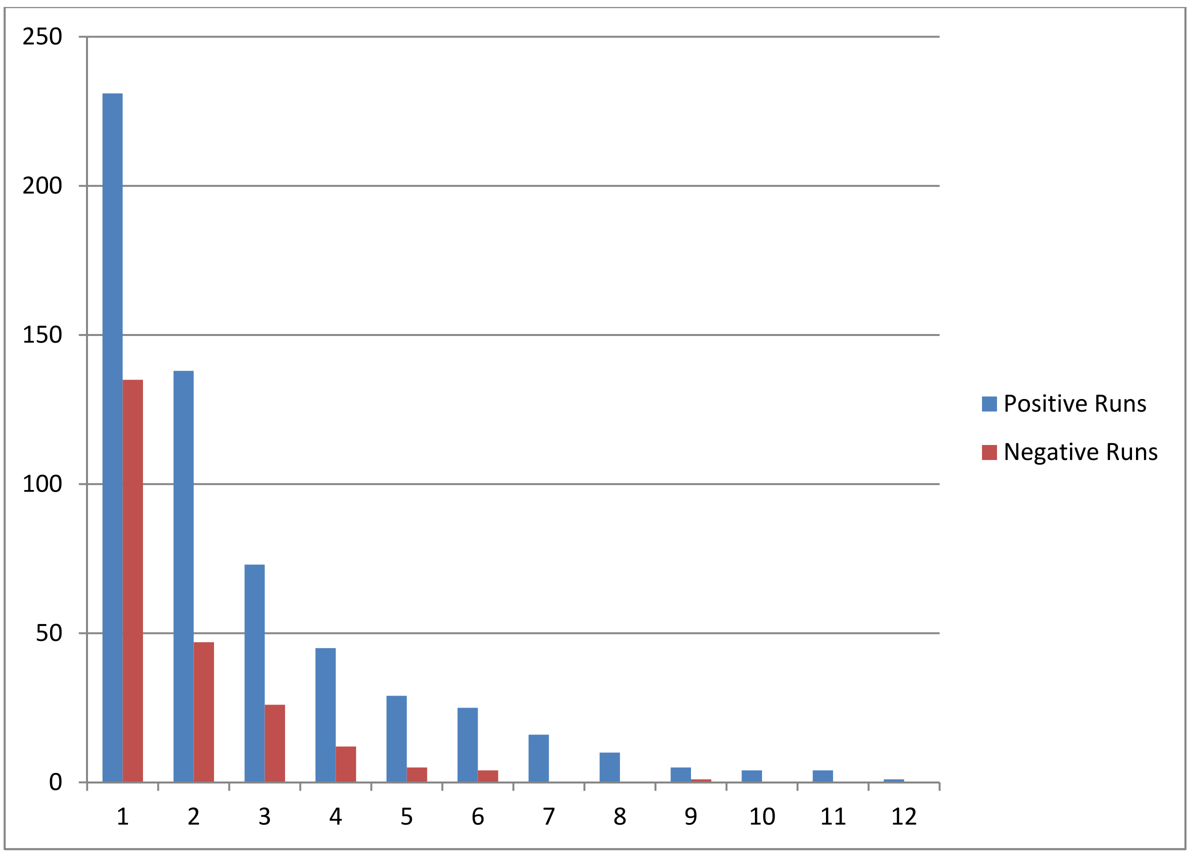
**Exhibit 9**
**Frequency of Positive and Above Average Returns for the S&P 500 Index: 1926-2008**




Thus, we also report historical data on the number of above-mean months each year. Most years have between 5 and 9 months with positive returns; never have all 12 monthly returns been positive. Thus, even in the heat of a great bull market, history suggests that investors will always had ample numbers of "down months" in which to invest.

An alternate way of looking at this issue is to consider the length of positive or negative "runs", or the number of consecutive months with the same sign. Exhibit 10 shows the incidence of positive and negative runs over the 1926-2008 period. About 42% of positive months are followed by negative returns (run length of 1), while another 23% of positive runs are followed by only one more positive return (run length of 2). The chance of a string of 5 or more consecutive positive returns is less than 10%. Again, the historical data suggest little danger of being permanently "on the sidelines" with the EDCA strategy.

**Exhibit 10**
**Frequency of Positive and Negative Runs: 1926-2008**




If investors allow a significant time-lag before adjusting their cash flows, this could affect the results. For an investor to implement the strategy on an individual account, the investor must watch their returns carefully and adjust their contributions accordingly on a timely basis. One way of doing this is to have the contribution automatically placed into a money market account, then to manually control the assets swept out of the money market account every week/month. Alternatively, a plan custodian might offer EDCA as an alternative to traditional dollar-cost-averaging, which would require the plan administrator to have a computer system that could accommodate such an option. The purpose of this paper is not to address all of the details of implementing the EDCA strategy, but rather to demonstrate the economic advantages of doing so. However, the EDCA strategy could be implemented for portfolios where the owner or portfolio manager has discretion over the size of the periodic cash flows.

## Conclusions

This paper presents a simple, intuitive investment strategy that improves upon dollar-cost-averaging (DCA) for investors making regular contributions to investment portfolios. The purpose of this paper is to present a practical investment strategy that is closer than dollar-cost-averaging to the optimal sequential strategy, yet retains the "hands off" attributes of dollar-cost-averaging that are appealing to behavioral investors. Our enhanced dollar cost averaging (EDCA) strategy takes account of new information by recognizing that a positive return makes stocks more expensive, and a negative return makes them cheaper.

Our simulation results show that the EDCA strategy reliably outperforms the DCA strategy. We document that EDCA nearly always delivers higher dollar-weighted returns, and delivers greater terminal wealth well between 60% and 95% of the time depending on the particular model specification. Furthermore, the variation of our EDCA model that allows for the additional monthly contribution to be conditional upon the size of the lagged return leads to an even greater enhancement in return over traditional DCA. Historical back-testing on U.S. equity indexes and mutual funds indicates that investor dollar-weighted returns can be enhanced by between 17 and 70 basis points per year simply by switching from DCA to EDCA. When back-tested using monthly returns from 2000-2009, EDCA provides almost no benefit for money market or taxable fixed income funds, but enhances dollar-weighted returns for 47 out of 48 equity funds.

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