

Automatic investment plans: realized returns and shortfall probabilities

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Abstract

We compare the realized returns and shortfall probabilities of automatic investment plans with those of lump sum investments. We do not assume a cash position and we use bootstrapping techniques to assess the performance differences. Our results indicate that the levels of realized returns from these two strategies are statistically identical for investment horizons from 1 year to 40 years, regardless of whether we take return autocorrelations or business cycles into account. Automatic investment plans, nevertheless, have higher shortfall probabilities for intermediate horizons. Investors relying on automatic investment plans should consider these probabilities and adjust their asset allocations accordingly. © 2007 Academy of Financial Services. All rights reserved.

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1. Introduction

Automatic investment plans have become increasingly popular in recent years. Under an automatic investment plan, an investor specifies upfront a dollar amount as his investment for each period, and the periodical investments continue automatically regardless of market situations. Examples of automatic investment plans include many defined contribution plans such as 401(k) and 403(b) plans. The recent enactment of the Pension Protection Act of 2006, which allows employers to enroll their employees into automatic investment plans, further

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underscores the importance of this unique investment schedule. Automatic investment plans are also widely available for investors on various financial products and even as features of investment accounts.

How do automatic investment plans affect investors' realized returns? Specifically, relative to lump sum investments that call for one-time capital commitment upfront, do automatic investment plans benefit or hurt investors on the investment returns and risk? The answers to these questions are keys for investors to evaluate their investment alternatives and to allocate their capital. On one hand, an automatic investment plan allows an investor with periodical investments to buy more shares of the underlying asset when its price is low and fewer shares when the price is high, a feature called dollar cost averaging. This feature could possibly reduce the cost of accumulating shares and prevent behavioral biases such as aversion to regret, cognitive errors, and the lack of self-control (Statman, 1995). On the other hand, the intrinsic rigidity/inflexible schedule of automatic investment plans may hinder investors' ability to respond to market situations (Constantinides, 1979). Given the popularity of automatic investment plans, it is especially important for us to understand how automatic investment plans may affect investors' realized performance on an underlying asset. In this paper we provide specific evidence addressing these issues.

We start by assessing the realized returns from automatic investment plans under various horizons, using the returns from lump sum investments on the same risky underlying asset as benchmarks. Different from previous studies that focus on dollar cost averaging, we do not assume a cash (risk-free) position in an automatic investment plan. Doing so allows us to isolate the effect of the unique investment schedule of an automatic investment plan on investors' realized returns. As Abeysekera and Rosenbloom (2000) point out, the return on the cash position can affect the relative superiority of lump sum investments and dollar cost averaging investments. Furthermore, combining a risk-free asset with a risky asset reduces the entire portfolio's expected return and risk when compared with the risky asset alone. Without a normative asset pricing model, a lump sum investment in a risky asset and an automatic investment plan in both a risk-free asset and the risky asset would not be comparable (Rozeff, 1994).

We further compare automatic investment plans with lump sum investments under three different scenarios: When time-series returns are independent, when returns are autocorrelated, and when returns are dictated by the contractionary or expansionary phases of business cycles. We use the latter two scenarios to examine more closely the path-dependent realized returns of automatic investment plans. To illustrate, suppose an investor faces two risky assets for two periods. Asset A has the period one return of 5% and the period two return of 10%. Asset B has the period one return of 10% and the period two return of 5%. A lump sum investment at the beginning of the first period would earn the return of 7.47% per period for both assets. An automatic investment plan investing a fixed dollar amount at the beginning of each period, however, would earn the return of 8.27% per period for asset A but 6.68% per period for asset B.

We use bootstrapping techniques including data resampling and residual resampling to simulate time-series returns from past data. We assess the statistical significance of the realized return differences between automatic investment plans and lump sum investments with bootstrapped p -values. Similar to Dubil (2004) and Trainor (2005), we define the

shortfall probability under an investment strategy as the probability that investors realize negative returns on their investments. We evaluate this probability across the bootstrapped samples. Unlike the Monte Carlo method commonly used in previous studies, the bootstrapping techniques do not require specific assumptions on return distributions or on utility functions. The less restrictive assumptions could prevent model-specific biases on the empirical tests (Fama, 1998). In addition, residual resampling allows us to build return autocorrelations into the simulated return series. Our focus on the path-dependent realized returns of automatic investment plans renders the bootstrapping techniques preferable.

If periodic returns are independent, we expect the levels of realized returns from an automatic investment plan and from a lump sum investment to be the same. As the investment horizon lengthens, the realized return per period from either investment should approach the true return per period by the (unknown) return generating process of the underlying asset. If periodic returns are not independent, however, an automatic investment plan may consistently outperform or underperform a lump sum investment because of the path-dependent nature of its realized returns. We examine the investment horizons from 1 year to 40 years.

With returns simulated on two broad market indexes from 1926 to 2005, our results indicate that automatic investment plans with monthly investments realize statistically the same levels of returns as corresponding lump sum investments. This finding holds across the investment horizons from 1 year to 40 years, and across the scenarios whether the returns are independent, autocorrelated, or dictated by the different phases of business cycles. On the other hand, the shortfall probabilities on automatic investment plans and lump sum investments are statistically indistinguishable for horizons of 1 year, 30 years, and 40 years. For intermediate horizons, automatic investment plans have significantly higher shortfall probabilities than lump sum investments. Only in one special case, the contractionary phases of business cycles, would automatic investment plans have consistently lower shortfall probabilities than lump sum investments. These results are robust with an alternative sample and under different specifications.

This research extends and complements previous studies that compare dollar cost averaging investments with lump sum investments. For instance, Knight and Mandell (1992), Williams and Bacon (1993), and Rozeff (1994) all document that lump sum investments outperform dollar cost averaging investments. Abeysekera and Rosenbloom (2000), on the other hand, suggest that the relative superiority of lump sum investments and dollar cost averaging investments depends on the parameters of their Monte Carlo simulation model. Dutil (2004) focuses on the risk of dollar cost averaging investments and finds that these investments provide lower conditional expected dollar shortfall than lump sum investments at the end of a holding period. Trainor (2005) further suggests that the within-horizon shortfall probabilities are lower for dollar cost averaging investments.¹ By excluding the cash position and using bootstrapping techniques, the results in this paper indicate that for very short and long investment horizons, automatic investment plans are actually as good as lump sum investments. Automatic investment plans neither benefit investors by dollar cost averaging nor hurt investors by their inflexible schedule. Statman (1995) justifies the use of dollar cost averaging under a behavioral framework. Our results provide an alternative explanation

for the puzzling popularity of automatic investment plans and dollar cost averaging investments (e.g., Leggio & Lien, 2003).

The finding that automatic investment plans suffer from higher probabilities of shortfall for intermediate horizons further suggests that investors relying on automatic investment plans for these horizons should take the higher probabilities of shortfall into account. For instance, investors may allocate a portion of their capital in automatic investment plans to less risky assets to reduce their exposure on the shortfall risk. This approach, however, will also reduce the expected return of the portfolio. The optimal asset allocation therefore depends on the risk aversion of an investor.

The rest of this paper is organized as follows: We describe the data and explain our methodology in the next section. The results and robustness checks are presented in Section 3. Section 4 concludes this paper.

2. Data and methodology

2.1. Data

Our samples use the monthly return series on the NYSE/AMEX/NASDAQ value-weighted index and the equally weighted index from the Center of Research in Security Prices (CRSP) database. The data cover the period from January 1926 to December 2005. The two indexes comprise of all securities listed on these three markets. The value-weighted index returns closely resemble the returns on large firms and the Standard & Poor's (S&P) 500 index. The equally weighted index returns, on the other hand, reflect returns in line with relatively small firms.

2.2. Methodology

2.2.1. Data resampling

To simulate independent returns from past data, we use the data resampling technique. This technique does not require the specification of a return generating process or a unique return distribution. It is therefore less restrictive than the Monte Carlo method.²

The simulated return series are generated by sampling with replacement from the pool of past returns. Each additional month in an investment horizon calls for one additional draw from the return pool. For instance, with the investment horizon of 40 year, we have 480 draws and therefore 480 return observations. This resampling technique keeps the distribution of the simulated returns the same as the unknown distribution implied by the original data, while at the same time it eliminates any return autocorrelation implied in the original return series. The resulting return observations, though indexed through time, are independent by design.

We assess the possible performance differences between automatic investment plans and lump sum investments under the investment horizons of 1 year, 3 years, 5 years, 10 years, 15 years, 20 years, 30 years, and 40 years. We simulate 50,000 return paths for each investment horizon and compare the annualized returns of the automatic investment plans

with those of the lump sum investments. Under the null hypothesis that these two investment strategies provide investors the same realized return, one strategy should not outperform the other consistently. We define the bootstrapped p -value as the probability that the realized return of the automatic investment plan is higher than the realized return of the lump sum investment. A p -value of 1% (99%) therefore indicates that the automatic investment plan underperforms (outperforms) the lump sum investment on the level of returns at the 1% significance level. We further define and calculate the shortfall probability under each strategy as the probability that an investment strategy provides investors a negative realized return over the entire investment horizon.

To assess the significance of the difference between the shortfall probabilities under these two strategies, we divide the 50,000 simulated return series into 100 subsamples. For each subsample, we calculate and compare the shortfall probabilities of these two strategies. Under the null hypothesis that these two investment strategies have the same shortfall probability, one strategy should not consistently provide a lower shortfall probability than the other strategy. We define the bootstrapped p -value in this case as the probability that the shortfall probability under the automatic investment plan is higher than the shortfall probability under the lump sum investment. A p -value of 1% (99%) therefore indicates that the automatic investment plan has a lower (higher) shortfall probability than the lump sum investment at the 1% significance level.

2.2.2. Residual resampling

The data resampling technique eliminates any possible time-series dependence of returns. Because the return performance of automatic investment plans has a path-dependent nature, we need a sample that can reflect the autocorrelation implied by the original return series to examine this nature more closely. We use the residual resampling technique to generate this sample. Specifically, we estimate first an AR(1) model on the original return series:

$$r_t = \beta_0 + \beta_1 r_{t-1} + \varepsilon_t \quad (1)$$

where r_t is the index return in month t . β_0 and β_1 are parameters with β_0 representing the mean return after considering the first-order return autocorrelation, and β_1 representing the first-order return autocorrelation coefficient. ε_t is the return residual in month t . We record the coefficient estimates ($\hat{\beta}_0$ and $\hat{\beta}_1$) and the return residuals (e_t).

The sample return series are then simulated by Eq. (1) over time: For month one ($t = 1$) return, we feed a seed of $r_{t-1} = r_0 = \hat{\beta}_0$ and a return residual (e_1) sampled with replacement from the recorded residual pool into Eq. (1). The simulated month one return is then:

$$r_1 = \hat{\beta}_0 + \hat{\beta}_1 r_0 + e_1 \quad (2)$$

We obtain the simulated month two return by feeding r_1 and another return residual (e_2) sampled with replacement from the residual pool into Eq. (1):

$$r_2 = \hat{\beta}_0 + \hat{\beta}_1 r_1 + e_2 \quad (3)$$

To let the simulated sample stabilize, we discard the first 100 observations from the simulated return series and use the 101th observation as the first monthly return for a given

Table 1 Statistics on the CRSP value-weighted and equally weighted index returns from January 1926 to December 2005

	Monthly returns				Number of monthly returns	
	Average	Standard deviation	Maximum	Minimum	Positive	Negative
Value-weighted index	0.0095	0.0545	0.3837	−0.2903	597	363
Equally weighted index	0.0130	0.0745	0.6659	−0.3131	591	369

Note: This table presents the summary statistics on the CRSP NYSE/AMEX/NASDAQ value-weighted index returns and the equally weighted index returns from January 1926 to December 2005.

investment horizon (e.g., Baker & Stein, 2004). The resulting sample carries the same autocorrelation and follows the same unknown distribution as the original return series governed by Eq. (1).

3. Results

3.1. Independent returns

Table 1 reports the summary statistics on the CRSP value-weighted and equally weighted index returns from January 1926 to December 2005. The average monthly return on the value-weighted index is 0.95%, and the average monthly return on the equally weighted index is 1.30%. Table 1 also shows the return standard deviations and the maximum and minimum monthly returns on these two indexes. The maximum and minimum monthly returns represent the upper and lower bounds for the simulated returns. The returns on the equally weighted index have a larger variability than the returns on the value-weighted index, as indicated by the larger return standard deviation and the wider return range. The number of months with either positive or negative returns, nevertheless, is similar on these two indexes.

Table 2 reports the realized returns and shortfall probabilities of automatic investment plans and lump sum investments, assuming independent monthly returns. Panel A shows the results based on the value-weighted index returns, and Panel B shows the results based on the equally weighted index returns. The reported annualized return represents the average value of the 50,000 simulated return series.

The results in Table 2 indicate that automatic investment plans realize statistically the same levels of returns as lump sum investments. For instance, with the value-weighted index as the underlying asset and the investment horizon of 1 year, the automatic investment plan earns a 12.73% annualized return and the lump sum investment earns 11.93%. The bootstrapped *p*-value of 0.51 suggests that, in only 51% of the 50,000 simulated cases the automatic investment plan earns a higher return than the lump sum investment. The return difference between the automatic investment plan and the lump sum investment is therefore

Table 2 Realized returns and shortfall probabilities of automatic investment plans and lump sum investments with independent returns

Horizon (years)	Annualized return			Shortfall probability		
	Automatic	Lump sum	<i>p</i> -value	Automatic	Lump sum	<i>p</i> -value
Panel A: Value-weighted index return						
1	0.1273	0.1193	0.51	0.2953	0.2884	0.66
3	0.1100	0.1062	0.51	0.2046	0.1860	0.91
5	0.1061	0.1031	0.52	0.1516	0.1306	0.93
10	0.1049	0.1020	0.53	0.0715	0.0558	0.95
15	0.1037	0.1014	0.53	0.0391	0.0263	0.91
20	0.1030	0.1009	0.53	0.0219	0.0133	0.89
30	0.1026	0.1006	0.54	0.0061	0.0030	0.75
40	0.1022	0.1004	0.55	0.0017	0.0008	0.43
Panel B: Equally weighted index return						
1	0.1811	0.1669	0.51	0.2996	0.2966	0.51
3	0.1517	0.1440	0.52	0.2044	0.1889	0.84
5	0.1446	0.1391	0.52	0.1487	0.1287	0.96
10	0.1400	0.1354	0.54	0.0721	0.0570	0.93
15	0.1381	0.1345	0.54	0.0366	0.0260	0.89
20	0.1377	0.1342	0.55	0.0196	0.0129	0.84
30	0.1366	0.1334	0.56	0.0056	0.0028	0.72
40	0.1354	0.1329	0.56	0.0014	0.0006	0.40

Note: This table presents the realized returns and shortfall probabilities of automatic investment plans and lump sum investments for the investment horizons from 1 year to 40 years. Assuming return independence, we simulate for each investment horizon 50,000 monthly return series based on either the CRSP NYSE/AMEX/NASDAQ value-weighted index returns or the equally weighted index returns from January 1926 to December 2005. The bootstrapped *p*-value for the annualized return is the probability that the realized return of the automatic investment plan is higher than the realized return of the lump sum investment. The bootstrapped *p*-value for the shortfall probability is the probability that the shortfall probability under the automatic investment plan is higher than the shortfall probability under the lump sum investment.

not significant. With the investment horizon of 40 years, the bootstrapped *p*-value of 0.55 still suggests an indistinguishable return difference between the automatic investment plan and the lump sum investment.

The results on shortfall probabilities, on the other hand, suggest that automatic investment plans have higher shortfall probabilities than lump sum investments under intermediate investment horizons. For instance, with the value-weighted index as the underlying asset, automatic investment plans have higher shortfall probabilities for horizons from 3 years to 15 years (significant at the 10% level). With the equally weighted index, automatic investment plans have higher shortfall probabilities for horizons from 5 years to 10 years. These results collectively suggest that dollar cost averaging does not reduce the cost of automatic investment plans, as automatic investment plans and lump sum investment earn virtually the same levels of returns. Furthermore, automatic investment plans have higher risk of shortfall for investors with intermediate horizons. For very short and long investment horizons, however, automatic investment plans and lump sum investments have statistically the same shortfall probabilities.

Table 3 Realized returns and shortfall probabilities of automatic investment plans and lump sum investments with autocorrelated returns

Horizon (years)	Annualized return			Shortfall probability		
	Automatic	Lump sum	<i>p</i> -value	Automatic	Lump sum	<i>p</i> -value
Panel A: Value-weighted index return						
1	0.1329	0.1245	0.51	0.3100	0.3040	0.63
3	0.1115	0.1070	0.52	0.2267	0.2108	0.82
5	0.1087	0.1049	0.52	0.1729	0.1505	0.89
10	0.1053	0.1023	0.53	0.0957	0.0767	0.96
15	0.1043	0.1015	0.53	0.0533	0.0384	0.92
20	0.1040	0.1013	0.54	0.0330	0.0226	0.93
30	0.1030	0.1008	0.55	0.0120	0.0073	0.82
40	0.1030	0.1009	0.55	0.0041	0.0018	0.66
Panel B: Equally weighted index return						
1	0.2054	0.1858	0.51	0.3373	0.3337	0.56
3	0.1596	0.1490	0.53	0.2491	0.2403	0.72
5	0.1500	0.1412	0.53	0.1996	0.1870	0.79
10	0.1451	0.1384	0.54	0.1151	0.1004	0.86
15	0.1403	0.1345	0.55	0.0718	0.0598	0.88
20	0.1401	0.1344	0.56	0.0461	0.0359	0.89
30	0.1380	0.1335	0.57	0.0190	0.0148	0.73
40	0.1377	0.1337	0.57	0.0076	0.0053	0.55

Note: This table presents the realized returns and shortfall probabilities of automatic investment plans and lump sum investments for the investment horizons from 1 year to 40 years. Assuming return autocorrelation, we simulate for each investment horizon 50,000 monthly return series based on either the CRSP NYSE/AMEX/NASDAQ value-weighted index returns or the equally weighted index returns from January 1926 to December 2005. The bootstrapped *p*-value for the annualized return is the probability that the realized return of the automatic investment plan is higher than the realized return of the lump sum investment. The bootstrapped *p*-value for the shortfall probability is the probability that the shortfall probability under the automatic investment plan is higher than the shortfall probability under the lump sum investment.

3.2. Autocorrelated returns

Because the realized returns of automatic investment plans are path-dependent, we examine the return performance and shortfall probabilities of automatic investment plans more closely with autocorrelated returns. The simulated return series are based on the estimated Eq. (1) as:

$$r_t = 0.0085 + 0.1037r_{t-1} + \varepsilon_t, \text{ for the value-weighted index returns, and}$$

$$r_t = 0.0103 + 0.2069r_{t-1} + \varepsilon_t, \text{ for the equally weighted index returns.}$$

These estimates indicate that the equally weighted index returns have a higher autocorrelation (0.2069) and a higher average return (1.03%) than the value-weighted index returns (0.1037 and 0.85%, respectively). Table 3 shows the results of the tests.

The results in Table 3 suggest that, even when we allow for return autocorrelations in the data, automatic investment plans and lump sum investments still earn similar levels of returns under the horizons from 1 year to 40 years. Automatic investment plans, nevertheless, have significantly higher shortfall probabilities for horizons from 10 years to 20 years with the value-weighted index as the underlying asset. With the equally weighted index, th

Table 4 Statistics on the CRSP index returns in the contractionary and expansionary phases of business cycles

	Monthly returns				Number of monthly returns	
	Average	Standard deviation	Maximum	Minimum	Positive	Negative
Panel A: Value-weighted index return						
Contraction	-0.0056	0.0811	0.3660	-0.2903	90	91
Expansion	0.0130	0.0455	0.3837	-0.2253	507	272
Panel B: Equally weighted index return						
Contraction	-0.0067	0.1065	0.6659	-0.3131	83	98
Expansion	0.0176	0.0641	0.6060	-0.2723	508	271

Note: This table presents the summary statistics on the CRSP NYSE/AMEX/NASDAQ value-weighted index returns and the equally weighted index returns in the contractionary and expansionary phases of business cycles from January 1926 to December 2005. During this period, the National Bureau of Economic Research (NBER) identifies 14 contractions and 15 expansions.

shortfall probabilities on automatic investment plans are statistically indistinguishable from those on lump sum investments.

3.3. Returns dictated by different phases of business cycles

We next examine the realized returns and shortfall probabilities of automatic investment plans when returns are dictated by the contractionary or expansionary phases of business cycles. The National Bureau of Economic Research (NBER) identifies 14 contractions (a total of 181 months) and 15 expansions (a total of 779 months) from January 1926 to December 2005. During this period, on average a full contraction lasts for 13 months and a full expansion lasts for 55 months. We use the index returns in one of these two phases to simulate the sample return series. Table 4 reports the summary statistics on the CRSP index returns during each of these two phases.

Table 4 shows that for both the value-weighted index and the equally weighted index, the average monthly return is negative during the contractionary phase and positive during the expansionary phase. Both indexes experience relatively more negative returns in the contractionary phase than in the expansionary phase. For instance, the average monthly value-weighted index return is -0.56% in the contractionary phase (return standard deviation = 8.11%) and 1.30% in the expansionary phase (return standard deviation = 4.55%). More than 50% of the monthly returns are negative in the contractionary phase and only 35% of the monthly returns are negative in the expansionary phase. These statistics suggest that negative returns will dominate the simulated return series in contractions and positive returns will dominate the simulated return series in expansions. The separation of these two phases of business cycles therefore allows us to examine whether the periodical investments of automatic investment plans benefit investors in down markets and hurt investors in up markets. For practical relevance, Table 5 presents the results for the investment horizons from 3 months to 24 months in contractions, and for the investment horizons from 1 year to 8 years in expansions.³

Table 5 Realized returns and shortfall probabilities of automatic investment plans and lump sum investments under business cycles

Horizon (months)	Annualized return			Shortfall probability		
	Automatic	Lump sum	<i>p</i> -value	Automatic	Lump sum	<i>p</i> -value
Panel A: Value-weighted index return						
Contraction (months)						
3	0.0870	0.0533	0.51	0.5502	0.5635	0.17
6	-0.0029	-0.0264	0.51	0.5820	0.6001	0.13
9	-0.0373	-0.0541	0.51	0.6093	0.6308	0.09
12	-0.0514	-0.0661	0.52	0.6242	0.6492	0.05
15	-0.0604	-0.0735	0.52	0.6355	0.6649	0.02
18	-0.0657	-0.0766	0.51	0.6460	0.6784	0.00
21	-0.0670	-0.0806	0.52	0.6611	0.6928	0.02
24	-0.0732	-0.0829	0.52	0.6697	0.7040	0.03
Expansion (years)						
1	0.1712	0.1662	0.50	0.1934	0.1748	0.90
2	0.1628	0.1595	0.51	0.1162	0.0958	0.95
3	0.1600	0.1577	0.51	0.0797	0.0562	0.98
4	0.1593	0.1568	0.51	0.0509	0.0350	0.98
5	0.1577	0.1557	0.52	0.0361	0.0219	0.99
6	0.1574	0.1554	0.52	0.0243	0.0128	0.96
7	0.1573	0.1553	0.52	0.0172	0.0076	0.97
8	0.1568	0.1549	0.52	0.0113	0.0058	0.85
Panel B: Equally weighted index return						
Contraction (months)						
3	0.2469	0.1547	0.51	0.5754	0.5884	0.17
6	0.0301	-0.0126	0.51	0.6050	0.6260	0.10
9	-0.0288	-0.0587	0.51	0.6273	0.6524	0.07
12	-0.0523	-0.0765	0.52	0.6421	0.6684	0.04
15	-0.0695	-0.0907	0.52	0.6563	0.6852	0.05
18	-0.0800	-0.0983	0.52	0.6686	0.7006	0.01
21	-0.0870	-0.1035	0.52	0.6829	0.7175	0.00
24	-0.0911	-0.1072	0.53	0.6882	0.7258	0.01
Expansion (years)						
1	0.2442	0.2345	0.51	0.1902	0.1738	0.86
2	0.2269	0.2197	0.51	0.1192	0.1002	0.96
3	0.2196	0.2151	0.51	0.0816	0.0601	0.96
4	0.2179	0.2130	0.52	0.0535	0.0383	0.94
5	0.2153	0.2112	0.52	0.0359	0.0226	0.97
6	0.2137	0.2102	0.52	0.0241	0.0141	0.93
7	0.2135	0.2101	0.52	0.0168	0.0085	0.92
8	0.2127	0.2095	0.53	0.0108	0.0057	0.85

Note: This table presents the realized returns and shortfall probabilities of automatic investment plans and lump sum investments. Using only the returns in the contractionary or expansionary phases of business cycles, we simulate for each investment horizon 50,000 monthly return series based on either the CRSP NYSE/AMEX/NASDAQ value-weighted index returns or the equally weighted index returns from January 1926 to December 2005. We report the results for the investment horizons from 3 months to 24 months in contractions, and for the investment horizons from 1 year to 8 years in expansions. The bootstrapped *p*-value for the annualized return is the probability that the realized return of the automatic investment plan is higher than the realized return of the lump sum investment. The bootstrapped *p*-value for the shortfall probability is the probability that the shortfall probability under the automatic investment plan is higher than the shortfall probability under the lump sum investment.

The results based on the value-weighted index returns (Panel A of Table 5) reveal that investors realize statistically the same levels of returns from automatic investment plans as they do from lump sum investments, whether in the contractionary phase or in the expansionary phase. For instance, the annualized return with the 3-month horizon in contractions is 8.70% for the automatic investment plan and 5.33% for the lump sum investment (p -value = 0.51). The annualized return with the 24-month horizon in contractions is -7.32% for the automatic investment plan and -8.29% for the lump sum investment (p -value = 0.52). We observe similar insignificant return differences in the expansionary phase. These findings suggest that, in terms of the level of returns, investors do not benefit from dollar cost averaging in down markets nor are investors hurt by dollar cost averaging in up markets. Untabulated results also confirm these findings for investment horizons up to 40 years.

The results on shortfall probabilities, nevertheless, suggest an advantage of automatic investment plans when compared with lump sum investments: A reduction in this probability in down markets. For instance, the shortfall probability for the automatic investment plan with a 9-month horizon is 60.93%, although it is 63.08% for the lump sum investment (p -value = 0.09). Under the horizons from 12 months to 24 months, automatic investment plans also have significantly lower shortfall probabilities than lump sum investments. In the expansion phase, automatic investment plans have higher shortfall probabilities than lump sum investments under the horizons from 2 years to 7 years. For the horizons of 1 year and 8 years, automatic investment plans and lump sum investments have statistically the same shortfall probabilities.

Panel A of Table 5 suggests that the primary advantage of automatic investment plans is to reduce the probability of shortfall in the case of market contractions. Untabulated results also show the lower shortfall probabilities of automatic investment plans for the horizons from 3 years to 40 years. Nevertheless, the contractionary phase in a business cycle typically lasts less than 2 years (i.e., 13 months). In the case of market expansions, lump sum investments have lower probabilities of shortfall than automatic investment plans for the horizons from 2 years to 7 years. The results based on the equally weighted index returns in Panel B of Table 5 are similar to our findings in Panel A.⁴

3.4. Alternative sample and specifications

3.4.1. S&P 500 index returns

We perform the same tests with the S&P 500 index returns from August 1962 to December 2005 to assess the robustness of our results. The (untabulated) results based on this alternative sample are similar to those based on the CRSP value-weighted returns, despite the fact that the S&P 500 index returns reveal a negative first-order autocorrelation during this more recent period.

3.4.2. Standardized residuals in autocorrelated returns

Because the volatility of the residuals identified through Eq. (1) underestimates the true residual volatility (see, for example, Davidson & MacKinnon, 1993, and Johnston & DiNardo, 1996), we use standardized residuals to adjust for this bias and simulate autocor-

related returns. The results with the standardized residuals in the simulation process are similar to Table 3.

3.4.3. Alternative lead-lag relations between index returns and business cycles

If stock returns lead real economic activities, using index returns in the specific months identified by NBER as in the contraction phase or in the expansion phase could possibly bias our results in Table 5, because of the mismatch of index returns and business cycles. To see whether our results are sensitive to the lead-lag relations, we allow the index returns to lead the business cycles by 3 months and by 6 months. These analyses produce results similar to Table 5 and suggest that the alternative lead-lag relations between index returns and business cycles do not affect our inferences.

4. Conclusion

We compare the realized returns and shortfall probabilities of automatic investment plans with those of lump sum investments using bootstrapping techniques. With samples simulated from the CRSP value-weighted and equally weighted index returns from January 1926 to December 2005, we consider scenarios in which monthly returns are independent, autocorrelated, or dictated by the contractionary or the expansionary phases of business cycles.

The results indicate that automatic investment plans realize statistically the same levels of returns as lump sum investments regardless of the scenarios, therefore casting doubt on the cost-reducing benefit of dollar cost averaging. On the other hand, these results also suggest that the inflexible schedule of automatic investment plans do not hurt investors on their realized returns.

Our analyses on the shortfall probabilities show that automatic investment plans have significantly higher shortfall probabilities than lump sum investments for intermediate horizons. For the horizons of 1 year, 30 years, and 40 years, the shortfall probabilities on automatic investment plans and lump sum investments are statistically indistinguishable. Only in one special case, the contractionary phases of business cycles, would automatic investment plans have consistently lower shortfall probabilities than lump sum investments. Nevertheless, the contractionary phase in a business cycle typically lasts less than 2 years.

Collectively, our results suggest that for very short and long investment horizons, automatic investment plans are as good as lump sum investments. Automatic investment plans neither benefit investors by dollar cost averaging nor hurt investors by their inflexible schedule. This finding provides a possible explanation for the puzzling popularity of automatic investment plans and dollar cost averaging investments. For intermediate horizons, nevertheless, automatic investment plans suffer from higher probabilities of shortfall. Investors relying on automatic investment plans for these horizons should take the higher probabilities of shortfall into account and adjust their asset allocations accordingly.

Notes

1. See also Leggio and Lien (2003) for a list of references on dollar cost averaging.
2. See, for example, Davidson and MacKinnon (1993) and Johnston and DiNardo (1996) for discussions on the resampling (bootstrapping) techniques.
3. We thank an anonymous referee for this suggestion.
4. The annualization of monthly returns, together with the relatively small sample size and the unique distribution of monthly returns in contractions, lead to the seemingly large average returns in Table 5 for the 3-month investment horizon in contractions. Without annualization, both automatic investment plans and lump sum investments have negative average monthly returns across the 50,000 simulations in this case. The annualization of monthly returns, nevertheless, has no effect on the bootstrapped p -values for the realized returns and shortfall probabilities.

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