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Long-Run Returns on Stock and Bond Portfolios: Implications for Retirement Planning

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This paper presents asset returns over long holding periods in a form useful for retirement planning. Time diversification, heretofore analyzed for lump-sum investments, still serves to reduce the risk of stock investments when funds are accumulated month by month. We consider investments in five stock and bond asset classes as well as various asset allocation strategies. Probability distributions are computed for retirement wealth over a range of investment horizons.

I. Introduction

Time diversification plays a key role in retirement planning decisions. Because of time diversification, the risk of meeting a particular wealth objective is reduced when risky assets with high expected returns are held over long periods of time. Individuals face investment accumulation periods of up to forty years early in their careers, so information about the long-run returns and risks of various asset classes is essential.

Existing research on time diversification must be modified for retirement planning. Levy (1978), Reichenstein (1986), and Butler and Domian (1991) assume "lump-sum" investments at the beginning of the holding period, with no other funds added except for reinvested portfolio earnings. However, retirement investments typically have monthly or yearly contributions which increase portfolio size throughout the holding period. Thus, returns in early years are not as important to retirement wealth as returns in later years.

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Most defined contribution pension plans give the asset allocation choice to the individual participant. For example, many college and university employees allocate retirement contributions between the CREF common stock fund and TIAA which has assets including bonds and mortgages. Additional choices are available through IRAs, 401(k) plans, and other tax-sheltered arrangements. Investors making periodic contributions to their retirement portfolios need to know the impact of their asset choice on ending wealth.

We use observed capital market history and an empirical resampling procedure to estimate retirement wealth distributions over various investment horizons. These distributions are inflation-adjusted so that retirement income can be stated in terms of today's purchasing power. The wealth distributions also reveal the likelihood of one asset class outperforming another over various holding periods. Along with stating total wealth at the beginning of retirement, we also calculate monthly payments from lifetime annuities so that investors can plan for their retirement incomes and lifestyles.

The next section reviews the existing time diversification literature. Section III describes the resampling procedure for estimating wealth distributions. Section IV presents and interprets the results from the estimations. Concluding remarks are made in Section V.

II. PREVIOUS RESEARCH

Levy (1978) demonstrates effects of time diversification by tabulating historical returns over various holding periods. He finds that common stocks outperformed Treasury bills in every 25-year holding period over 1926–1977. By using one-year overlaps, Levy constructs twenty-eight 25-year periods from the 52 years. However, as Levy observes, overlapping holding periods are not independent.[1] If common stocks had risen by 1000 percent in January 1952, this amazing return would be included in all but three of Levy's 25-year periods. Distributions based on overlapping periods thus misrepresent the true 25-year return distributions.

A way out of this problem is to use the observed history of stock and bond returns in a more creative way. One approach is to assume stock and bond returns are normally distributed and then derive the time diversification impact of longer holding periods. Reichenstein (1986) uses this method to show the manner in which portfolio risk depends on the holding period.

A simulation model can also prove helpful in time diversification research. This is an especially attractive alternative for researchers convinced of fundamental differences between past and future real return distributions. For example, Leibowitz and Langetieg (1989) construct models assuming a 4 percent stock risk premium over bonds rather than the 7 percent common stock/Treasury bond premium observed since 1926. A lower stock/bond risk premium decreases the relative advantage of stocks over bonds for both short and long holding periods. The disadvantage of this technique is that simulation models are often ad hoc and reflect the creator's preconceptions regarding the relevant forces driving asset returns.

We follow the empirical resampling procedure of Butler and Domian (1991). In contrast to the simulation model of Leibowitz and Langetieg, this approach uses only the observed history of stock and bond returns. It requires two conditions for the empirical distribution: 1) random draws must be independent over time, and 2) the moments of the distribution must not change over time.[2,3] A full description of this procedure is presented in the next section.

III. The Resampling Procedure

The standard data source in the time diversification literature is the Ibbotson monthly return indices which date back to 1926 (see Ibbotson 1991). We use Ibbotson's real (inflation- adjusted) returns for five indices: common stocks, small stocks, corporate bonds, Treasury bonds, and Treasury bills. Our study covers 65 years from 1926 through 1990, a time span of 780 months. Table 1 presents summary statistics of the time series.

An empirical resampling procedure is used to construct the distribution of retirement plan returns. We first explain the technique with an illustrative example of a 30-year accumulation period, and then go on to show how this can be modified for other investment horizons. Suppose an individual intends to make monthly retirement contributions for 30 years. At the end of this accumulation period, the total accumulated savings amount is used to purchase a single-premium lifetime annuity with monthly payments. For each dollar of monthly investment during the accumulation period, we want to identify the accumulated wealth and the size of the monthly annuity payment.

Based on observed capital market history, probability distributions are determined as follows:

TABLE 1
The Historical Return Series

Statistic	*Common Stocks*	*Small Stocks*	*Corporate Bonds*	*Treasury Bonds*	*Treasury Bills*
Mean	.0072	.0105	.0019	.0014	.0004
St. Dev.	.0589	.0902	.0211	.0231	.0057
Autocorrelation	.1011	.1557	.1992	.0891	.5368
Cross Correlations					
Small Stocks	.8494				
Corp Bonds	.2383	.1895			
T-Bonds	.1932	.1143	.8481		
T-Bills	.0804	.0262	.3289	.3323	

Note: Real monthly time series for 1926–1990 from Ibbotson Associates.

1. Randomly select one of the 780 months. Record the observed real return for this month for each asset class.
2. Do this random selection 360 times with replacement to construct 30 years of monthly returns.
3. Compound and accumulate the returns assuming additional real monthly investments of the same dollar amount.
4. Do this procedure 10,000 times to generate wealth distributions from the observed history of real monthly returns.
5. Divide the ending totals by an annuity factor to get the monthly payments throughout retirement.

This procedure can easily be modified. First, the accumulation period in step 2 can be shortened or lengthened. The next section shows results for 10, 20, 30, and 40-year accumulation periods. Second, various asset allocation strategies can be considered, using different mixes of the asset classes. Examples are given in the next section. Third, step 3 can be modified to allow changes in the monthly investment amount, perhaps as real earnings increase in later years of life. Finally, the annuity factor in step 5 can be changed to reflect different rates of return.

IV. Results

Distributions of ending wealth (i.e., at the end of the accumulation period) are shown in Table 2. Selected percentiles are given for 10, 20, 30, and 40-year accumulation periods. For each of five asset classes, the values are ending wealth per dollar of real monthly contribution.

Consider the illustrative 30-year accumulation period discussed in the previous section. At the median (fiftieth percentile), a one-dollar monthly investment in common stocks totals $1,194 after 30 years. Small stocks produce more, $1,680, while corporate bonds, Treasury bonds, and Treasury bills provide substantially less. Because these are medians, there are equal chances of getting either more or less than these amounts, based on observed history. The distributions for common stocks and small stocks are skewed to the right so that their means are substantially higher than their medians.[4]

This probabilistic interpretation can be carried a step further to make relative comparisons between stocks and bonds. For the 30-year accumulation period, the common stock distribution crosses the corporate bond distribution between the 3rd and 4th percentiles. This implies a less than four percent chance of ending up with lower wealth from diversified common stock investments than from corporate bonds over a 30-year accumulation period. The chance is even smaller for common stocks versus Treasury bonds, since these distributions cross at the second percentile.

With the 20-year accumulation period, there is still just a small risk that common stocks will underperform bonds. It is only when the accumulation period is reduced to 10 years that the risk is more substantial. Here the common stock

TABLE 2
Probability Distributions of Ending Wealth

Accum. Period	*%ile*	*Common Stocks*	*Small Stocks*	*Corporate Bonds*	*Treasury Bonds*	*Treasury Bills*
	5	92	76	107	102	116
	25	133	129	121	117	120
10 Yrs.	50	173	190	133	129	123
	75	228	294	145	143	126
	95	345	567	168	166	130
	5	202	161	216	199	232
	25	345	350	259	241	244
20 Yrs.	50	515	638	296	277	253
	75	782	1,232	338	321	262
	95	1,458	3,355	415	399	274
	5	363	283	334	296	350
	25	715	752	423	378	373
30 Yrs.	50	1,194	1,680	496	448	390
	75	2,055	3,824	586	541	407
	95	4,697	14,544	757	709	432
	5	582	460	466	396	470
	25	1,346	1,574	610	528	508
40 Yrs.	50	2,512	4,063	742	650	533
	75	4,810	11,458	907	805	560
	95	13,253	52,927	1,239	1,112	602

Note: Ending wealth per dollar of real monthly contribution over n-year (n = 10, 20, 30, 40) accumulation periods.

distribution crosses the Treasury bond distribution at the 12th percentile, and common stocks cross corporate bonds at the 16th percentile.

The Table 2 figures are based on contributions made to a single asset class over the entire accumulation period. However, few investors behave this way. Instead, contributions are typically divided among two or more asset classes. A diversified strategy increases wealth at the lowest percentiles of the distribution (but decreases wealth at the highest percentiles) when there are relatively low cross-correlations between the asset classes being mixed. Table 3 shows three representative mixes of common stocks and corporate bonds, which have a monthly cross-correlation of 0.24.[5] One hundred percent stock and bond columns from Table 2 are also shown for comparison.

Consider a 30-year accumulation period. Between the second and tenth percentiles (see the fifth percentile in Table 3) there is greater wealth from a 50–50 stock/bond mix than from the other proportions. Furthermore, Samuelson (1990) shows that a 50–50 buy-and-hold mixture is superior to a portfolio which randomly switches between 100 percent stock and 100 percent bonds throughout the holding period.[6]

TABLE 3
Probability Distributions of Ending Wealth for Stock/Bond Mixes

		Asset	*Allocation of contributions to each asset*				
		Stock:	*100%*	*75%*	*50%*	*25%*	—
Accum. Period	*%ile*	*Bonds:*	—	*25%*	*50%*	*75%*	*100%*
	5		92	100	108	113	116
	25		133	134	133	130	120
10 Yrs.	50		173	165	155	144	123
	75		228	204	180	161	126
	95		345	277	227	189	130
	5		202	227	242	243	232
	25		345	344	327	299	244
20 Yrs.	50		515	462	405	349	253
	75		782	637	511	409	262
	95		1,458	1,042	729	523	274
	5		363	396	413	397	350
	25		715	670	610	526	373
30 Yrs.	50		1,194	989	808	638	390
	75		2,055	1,491	1,080	785	407
	95		4,697	2,820	1,688	1,061	432
	5		582	665	671	615	470
	25		1,346	1,230	1,053	845	508
40 Yrs.	50		2,512	1,980	1,488	1,058	533
	75		4,810	3,237	2,094	1,350	560
	95		13,253	6,901	3,588	1,923	602

Note: Ending wealth per dollar of real monthly contribution over n-year (n = 10, 20, 30, 40) accumulation periods. Contributions are allocated between common stock and corporate bonds.

Asset allocations between other security classes have less interesting results. Common stocks and small stocks have a .85 correlation, so there is little risk reduction benefit through diversification. Because of this relatively high correlation, wealth at each percentile of the common stock/small stock distribution is approximately equal to the weighted average of wealth at the same percentiles of the single-asset distributions. A similar result is obtained for mixtures of stock and Treasury bills, despite their near-zero correlation. Real monthly T-bill returns have stayed near zero for most of the 1926–1990 period. The small standard deviation in the Treasury bill time series results in a near-linear increase in both expected return and standard deviation as greater proportions of wealth are placed in risky stock.

Many brokerage services and financial planners advocate investment in common stock early in one's career with a gradual shift to bonds as retirement approaches. The retirement-wealth effects of several versions of this strategy are illustrated in Table 4 for a 30-year accumulation period.

TABLE 4
Changing the Stock-Bond Mix

	Asset	*Years of contributions to each asset*				
	Stock:	*1–10*	*1–15*	*1–20*	*1–25*	*1–30*
%ile	*Bonds:*	*11–30*	*16–30*	*21–30*	*26–30*	—
5		393	391	383	373	363
25		564	605	647	678	715
50		765	867	983	1,087	1,194
75		1,083	1,304	1,545	1,787	2,055
95		1,970	2,536	3,185	3,912	4,697

Notes: Ending wealth per dollar of real monthly contribution over 30-year accumulation periods. The asset allocation is initially 100% common stock. In later years, new contributions are invested in corporate bonds and stock accumulations are gradually shifted to bonds. The portion transferred at the end of year n is $1/(30 - n + 1)$.

Consider the first column of the wealth distributions in Table 4. One-dollar real monthly contributions are invested in common stock during the first 10 years. Beginning in year 11, new contributions are put into corporate bonds, and at the end of year 11, 1/20th of the stock total is moved to bonds. The transfer proportion rises to 1/19 in year 12, 1/18 in year 13, and so on until year 30 when all remaining stock holdings are redeemed. As before, figures in the table show percentiles of ending wealth.

Other columns in Table 4 extend the stock contribution period to 15, 20, 25, and 30 years, with the 30-year column taken from Table 2. The wealth distributions cross around the eighth percentile. This means that there is only an eight percent chance of ending up with less wealth in an all-stock strategy than in a strategy which shifts to bonds earlier in the accumulation period. Shifting to bonds early in the accumulation period also gives up much of the upside potential of the all-stock strategy.

Table 5 illustrates the effect of changing the retirement age when investment contributions begin at age 30. All contributions are invested in common stock. The figures show monthly annuity payments from a lifetime annuity following retirement at age 60, 65, or 70. Calculations are based on mortality data for men[7] in the *1990 Life Insurance Fact Book* and a monthly discount rate of .0019, the average real monthly corporate bond return over 1926–1990.[8]

Monthly annuity payments increase dramatically as the retirement age is increased. This is due to the combined influence of two factors: the higher ending wealth from a longer accumulation period, and a shorter remaining lifetime over which to receive annuity payments.

The figures in Tables 2 through 5 assume the monthly contribution amount remains constant throughout the accumulation periods. Adding a growth rate to the contributions increases ending wealth and annuity amounts. For example, consider

TABLE 5
Lifetime Annuity Payments for Different Retirement Ages

	Retirement Age		
Percentile	*60*	*65*	*70*
5	1.76	2.71	3.97
25	3.47	5.58	9.17
50	5.80	9.92	17.12
75	9.99	18.07	32.78
95	22.82	44.28	90.33

Notes: Annual payments from a lifetime annuity per dollar of real monthly contribution. Contributions begin at age 30 and continue until retirement at ages 60, 65, or 70. Investments are in common stock throughout the accumulation period.

the 1,194 median ending wealth for common stock contributions over 30 years (Table 2). The median increases to 1,419 with two percent annual growth in real contributions, and climbs to 2,031 with 5 percent growth. The corresponding corporate bond totals increase from 496 to 651 and then to 1,024. However, growth has little effect on crossing points of the distributions. For example, 30-year common stock and corporate bond distributions still cross around the 4th percentile. The relative shapes and orderings of the distributions presented in Table 2 are retained.

V. CONCLUSION

The return distributions and the resampling procedure of this paper can be used by both individuals and financial planners. Probability distributions help determine the size of monthly retirement contributions which are needed to meet a long-term goal. The resampling procedure can adapt results to a particular investor's investment needs. Since all results are in real (inflation-adjusted) terms, retirement incomes are conveniently stated in terms of today's purchasing power.

The most striking result is the large advantage held by common stock investments over bonds for longer accumulation periods. As the accumulation period lengthens, stock investments become increasingly less "risky" than bonds. A given monthly investment in stocks can offer a reasonable chance of meeting a long-term investment goal, while the same amount invested in bonds generally has a smaller chance of meeting that goal. Based on capital market history, we find that over a 30-year accumulation period there is less than a four percent chance that common stocks will underperform corporate bonds. Despite the short-term risks, the stock market is the best bet for most long-term retirement investments.

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NOTES

1. This point is emphasized by McEnally (1985).
2. The true moments of the distribution are unknown. The sample mean and variance over 1926–1990 are only estimates of these parameters.
3. Butler and Domian (1991) show that small positive autocorrelations in the historical stock and bond series have little impact on return distributions produced by the resampling methodology.
4. The means of the common stock end-of-period wealth distributions are 190 (10 years), 636 (20 years), 1,705 (30 years), and 4,205 (40 years). Small stock distributions have means of 239 (10 years), 1,086 (20 years), 4,020 (30 years), and 14,082 (40 years).
5. The cross-correlation between common stocks and Treasury bonds is 0.19, resulting in distributions which are very similar to those in Table 3.
6. Samuelson (1990) considers a lump-sum portfolio without additional monthly contributions. The amounts held in each asset class must be rebalanced to maintain the 50–50 mix.
7. Lower mortality for women produces lower monthly annuity amounts.
8. Corporate bonds comprise over 40 percent of the assets of U. S. life insurance companies (see the *1990 Life Insurance Fact Book*).

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