Volume Title: Topics in the Economics of Aging

Volume Author/Editor: David A. Wise, editor

Volume Publisher: University of Chicago Press

Volume ISBN: 0-226-90298-6

Volume URL: http://www.nber.org/books/wise92-1

Conference Date: April 5-7, 1990

Publication Date: January 1992

Chapter Title: Stocks, Bonds, and Pension Wealth

Chapter Author: Thomas E. MaCurdy, John B. Shoven

Chapter URL: http://www.nber.org/chapters/c7098

Chapter pages in book: (p. 61 - 78)

2 Stocks, Bonds, and Pension Wealth

Thomas E. MaCurdy and John B. Shoven

For many people, the present value of their future pension annuity is their largest financial asset. The retirement income may come from a variety of pension accumulations, including defined contribution plans, defined benefit plans, individual retirement accounts, Keogh plans, and tax deferred annuity plans. With many of these accumulation vehicles, the individual participant bears the responsibility of determining the assets in which the funds are invested and bears any uncertainty about the rate of return that will be realized on those assets. In choosing between stocks and bonds for their pension accumulation vehicle, most people probably know that bonds have a lower average return and a lower variance in return; bonds offer additional "safety" at the expense of a lower expected outcome. While this risk-return trade-off is both correct and well understood for short-term investment horizons, the extent to which it applies for long holding periods is not clear. For many workers, the time between the current contribution to the retirement account and the purchase of an annuity is thirty years or more. What is the relative risk and return on stocks versus bonds for such a long horizon? The pension participant typically not only has a long horizon but also makes many contributions throughout his or her career. For example, faculty at Stanford University make payments to their retirement accounts twice each month over their term of employment. How does such a pattern of purchase affect the relative desirability of stocks versus bonds as pension accumulation assets? Finally, most

Thomas E. MaCurdy is professor of economics, Department of Economics, and senior fellow, Hoover Institution, Stanford University, and a research associate of the National Bureau of Economic Research. John B. Shoven is professor of economics, Department of Economics, and director of the Center for Economic Policy Research, Stanford University, and a research associate of the National Bureau of Economic Research.

This research was supported by the Center for Economic Policy Research at Stanford University. The authors would like to thank Steven N. Weisbart of TIAA-CREF for both advice and valuable data. They also would like to acknowledge the excellent research assistance of Stanford graduate students Bart Hamilton and Hilary Hoynes.

individual retirement accounts, Keogh plans, and defined contribution plans allow the participant not only to choose which assets are purchased with new contributions but also to move existing accumulations between asset categories. This raises the question of the desirability of gradually moving stock accumulations into bonds late in one's career. Such an option offers the potential advantage that one's retirement annuity would depend on the value of the stock portfolio at several selling dates rather than just its value on the date of purchase of the annuity.

Several papers investigate the effect of the length of investment horizon on optimal portfolio composition (e.g., Fischer 1983; and Merton and Samuelson 1974). Typically, these papers attempt to estimate the stochastic processes generating the returns on different assets, within some assumed class of models, and then determine optimal portfolios based on the maximization of expected lifetime utility, with the form of the utility function somewhat arbitrarily chosen. In general, these studies do not find that the length of the horizon unambiguously changes the optimal portfolio mix between stocks and bonds.

Our approach is quite different from the existing literature, and our results are more striking. We examine how some naive investment strategies for pension accumulations would have performed for employment careers of varying length between 1926 and 1989. Given a strategy, we calculate the implied value for the pension account at the time of retirement for all possible completed careers of a specified horizon within the sixty-four-year period. We consider only strategies in which investors allocate their pension contributions either entirely into stocks (with all dividends and other returns reinvested in stocks) or entirely into bonds (with interest reinvested in bonds). These strategies are not optimal in any sense since they ignore any market timing issues as well as standard portfolio theory. We then consider some strategies for converting from stocks to bonds as a worker approaches retirement, but we do not attempt to determine the optimal portfolio composition as a function of years until retirement. Despite these limitations, we find that an "all stocks" strategy dominates all other investment policies considered for all career lengths of twenty-five years or longer. By "domination," we mean that an all stocks allocation would have generated a larger pension accumulation for every career that ended in retirement over the period 1926–89.

Our findings have important implications for pension investment policies, and they suggest that the vast majority of people choose the wrong accumulation strategies. Not only are our results applicable to defined contribution plans, but they are also relevant for defined benefit pension programs and for other long-horizon saving targets.

2.1 Stock and Bond Returns

For calculating pension accumulations, our primary data source is the monthly-total-return statistics for stocks and bonds assembled by Ibbotson

Associates and published in their *Stocks, Bonds, Bills and Inflation: 1990 Yearbook*. For stock accumulations we use their monthly figures for the Standard and Poor's 500 Stock Composite Index (S&P 500), and for bond portfolio accumulations we use their monthly long-term corporate bond series, which is based on an index compiled by Salomon Brothers for long-term, high-grade corporate bonds. Both the series are available from December 1925 to December 1989.

The statistics of the annual inflation-adjusted returns for the S&P 500, for long-term corporate bonds, and for T-bills are shown below for 1926–88:

Asset	*Arithmetic Mean (%)*	*Standard Deviation (%)*
S&P 500	8.8	21.1
Long-term corporates	2.4	10.0
U.S. Treasury bills	.5	.5

Note that equities have an average yield premium of 6.4 percent over long-term corporate bonds. These mean real rates of return imply that $1.00 invested in December 1925 in the S&P 500 would have grown with dividends reinvested to roughly $76.00 in real terms by the end of 1989. One dollar invested in long-term corporate bonds would have grown to only $3.62 in constant dollar terms, whereas $1.00 invested in T-bills (and rolled over for the sixty-four years) would have grown to a real $1.37.

In another paper (MaCurdy and Shoven 1990), we document that stock investments generated higher returns for all holding periods twenty years and longer over the period 1926–89. Any one-time investment held for more than twenty years (with returns reinvested) would show a higher return if the asset was the S&P 500 than if it was a diversified portfolio of bonds, regardless of the date of purchase and the date of sale. The size of the equity premium is a fairly well-known puzzle since it seems to indicate an implausible degree of risk aversion. Our results in this other study suggest that holding a diversified portfolio including bonds rather than a pure stock portfolio for a period of more than twenty years would require an almost infinite degree of risk aversion since there has never been a span of time for which this strategy would be profitable.

We recognize that pension participants did not have the precise investment vehicles that we use to represent the returns on stock and bond funding strategies. Index funds, which nearly exactly reproduce the Ibbotson series, have been available only for the past few years. However, the S&P 500 index is a standard benchmark against which other diversified stock portfolios are compared.

In our pension accumulation calculations presented below, we attempt to capture the situation faced by college professors in making choices between CREF (a broadly diversified common stock portfolio) and TIAA (a bond portfolio). To compare the rate of return on the S&P 500 with the return on CREF, figure 2.1 plots the two annual rate-of-return series. The correspondence between the two series is so strong that one can barely identify the presence of

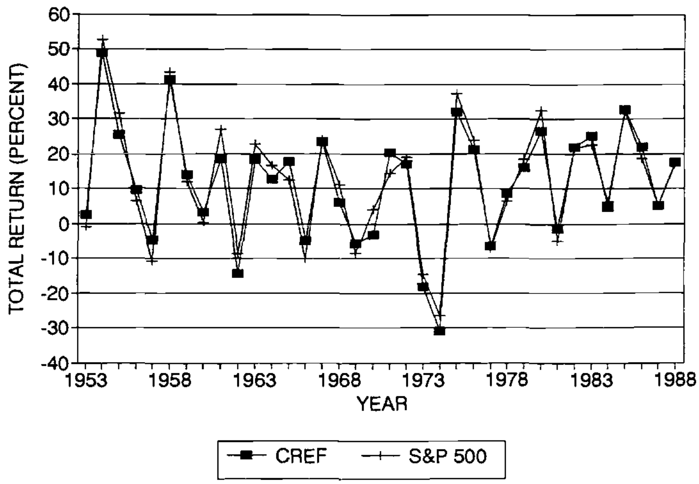

Fig. 2.1 Annual total rate of return on CREF and the S&P 500

two plots. We interpret this finding to indicate that the Ibbotson series for stocks is a reliable proxy for CREF's rate of return.

The bonds making up TIAA are higher yield and lower quality than those in the Ibbotson index. The Salomon Brothers long-term corporate bond index is a measure of the return earned by portfolios of high-grade corporate bonds. Funds that concentrate on private placements, "high-yield" bonds, and debt contracts with equity "kickers," such as TIAA, may perform differently than the Salomon Brothers index. Therefore, we feel that, while the Ibbotson bond index is completely satisfactory as a measure of the return on high-grade corporate bonds, it is a somewhat less satisfactory proxy for TIAAs returns.

2.2 Pension Accumulations

To characterize the implications of alternative investment strategies in pensions, we require a specification for the life-cycle profiles describing the earnings of cohorts over time, combined with an assumption about the fraction of earnings invested in pensions at each age. We formulate profiles designed to measure the earnings of academics over the period 1926–89. We further assume that each person contributes a fixed fraction of his current earnings to his pension fund each month throughout his working career. While we consider the case of college professors in carrying out this exercise, we believe that our findings are broadly applicable to any pension system where contributions are made periodically and are proportional to earnings.

2.2.1 Construction of Earnings Profiles

To describe our formulation of earnings profiles, let $\omega(c, \alpha)$ denote the annual nominal earnings of individuals who started jobs as assistant professors in September of the calendar year c when these persons reach α years of academic experience. The variable c indexes the cohort to which an individual belongs; it signals the academic year in which the group enters the profession. Assuming that all individuals making up an entry cohort are the same age in year c, the variable α equals the age of the cohort in the current year minus the cohort's age at the time of entry. With the variable t introduced to represent the relevant calendar year, the quantity $\omega(c, t - c)$ gives the annual earnings of cohort c in academic year t.

To construct the earnings quantities $\omega(c, \alpha)$, we combine data on academic salaries from several sources. From the *Campus Report* published by Stanford University on 22 March 1989, we acquired information on "cross-sectional" wage profiles for the academic year 1988–89. This publication reports graphs of the median of the annual salaries of assistant, associate, and full professors as functions of their seniority, which corresponds to a plot of the function $\omega(t - \alpha, \alpha)$ against α. Using data from the *Campus Report* to construct linear salary schedules for the year $t = 1988$ for assistant, associate, and full professors, we developed the following cross-sectional profile:

$$(1)\quad \omega(1988 - \alpha, \alpha) \equiv g(\alpha) = \begin{cases} 34{,}039 + 640\,\alpha & \text{for } \alpha = 0, 1, \ldots, 5; \\ 43{,}357 + 1{,}725(\alpha - 6) & \text{for } \alpha = 6, 7, \ldots, 10; \\ 64{,}012 + 622(\alpha - 11) & \text{for } \alpha \geq 11. \end{cases}$$

This formulation presumes that an individual spends six years as an assistant professor, five years as an associate professor, and the remainder of his or her career as a full professor.

Combining this cross-sectional profile with data on the growth of faculty salaries over the period 1926–89 provides sufficient information to calculate values for the annual earnings of all cohorts over this period. Define $r(t)$ as the annual nominal growth in faculty salaries. Assuming that wage growth in each year exerts a common influence on the earnings of all cohorts in that year yields the result:

$$(2)\qquad \omega(c, t - c) = \frac{g(\alpha)}{\prod_{k=t+1}^{1989} [1 + r(k)]}$$

where the spline function $g(\alpha)$ is given by (1). We impute values for the growth rates $r(t)$ for the years $t = 1926, \ldots, 1989$ from three distinct sources. Over the period 1929–65, we compute growth rates as $r(t) = [\text{Ave}(t) - \text{Ave}(t - 1)]/\text{Ave}(t - 1)$ where Ave(t) represents the average annual salary in year t of full professors in the University of California system reported in *The Centennial Record of the University of California* (1967). Over the period 1966–67, we calculate $r(t)$ with Ave(t) designating the average annual salary of full-time faculty at Stanford University reported in the *AAUP Bulletin,* published in the summers of 1966 and 1967 by the American Association of University Professors. Finally, over the period 1968–89, we construct $r(t)$ using the average annual salary of full professors at Stanford University as the measure of Ave(t), which comes from unpublished data supplied by the Provost's Office of Stanford.

2.2.2 Pension Values with Constant Allocation Policies

To calculate the accumulation of pensions, we assume that an individual of cohort c invests a fixed fraction of $\omega(c, t - c)$ in each year t over his or her entire working career. We consider careers of twenty-five, thirty, thirty-five, and forty years for those cohorts who entered and retired during the period 1926–89. A pure stock pension strategy refers to a policy whereby individuals allocate all their contributions to stocks. A pure bond strategy corresponds to all contributions invested in bonds. To compare the performance of these two pension policies, we calculate the ratio of what a person would have accumulated at the time of retirement by adopting a pure stock strategy to the accumulation associated with a pure bond approach. This ratio is independent of the absolute level of salaries and the fraction of salary applied to retirement accumulations (as long as that fraction is constant).

Figures 2.2–2.5 present plots of these ratios evaluated at the year of retirement for careers of twenty-five, thirty, thirty-five, and forty years, respectively. The numbers associated with these plots are reported in table 2.1 under the columns entitled "Stock(1)." The term "Stock(1)" signifies that an individual following a pure stock strategy makes only one transfer out of stocks at the very end of his or her career; there are no transfers from stocks to bonds just prior to retirement in an attempt to reduce risk.

Figure 2.2 shows the results for a twenty-five year career. We feel that this is an improbably short career for retirement accumulation (particularly for professors whose plan is almost completely portable from one employer to another). The ratio ranges from 1.17 to 5.06 with an average value of 2.64. That is, even for careers this short, accumulation in stocks has always led to more wealth (and a proportionately larger annuity). On average, a 100 percent stock strategy would have resulted in more than two and a half times as much retirement wealth as a 100 percent long-term corporate bond strategy. For retirements in the 1980s, the ratio ranges from 1.28 to 1.78, averaging 1.48. While these ratios are small relative to those in the three to five range for the mid-1950s to mid-1960s, they still indicate that the stock accumulator always did better than the bond accumulator, and by a very significant amount.

Figure 2.4 shows our calculations of the same ratio for the more realistic career length of thirty-five years. With this horizon, the ratio ranges from 1.56 to 6.25, averaging 3.58. Thus, the person who systematically accumulated stocks over a thirty-five-year career always ended up with at least 56 percent more pension wealth than someone who made the same pattern of contributions to a portfolio consisting of only long-term corporate bonds. On average,

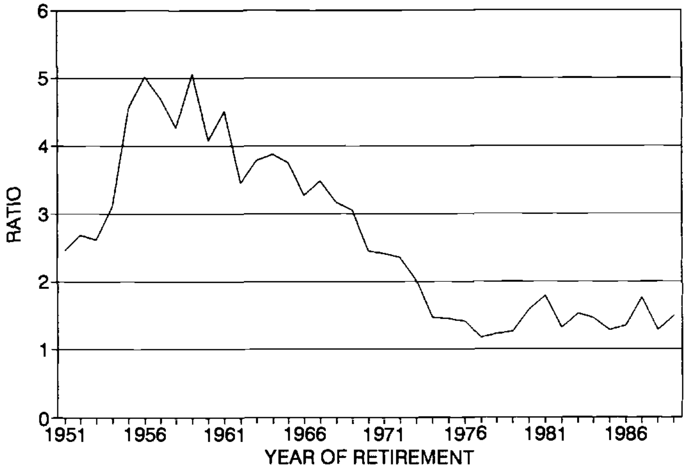

Fig. 2.2 Ratio of stock to bond accumulation for a twenty-five-year career

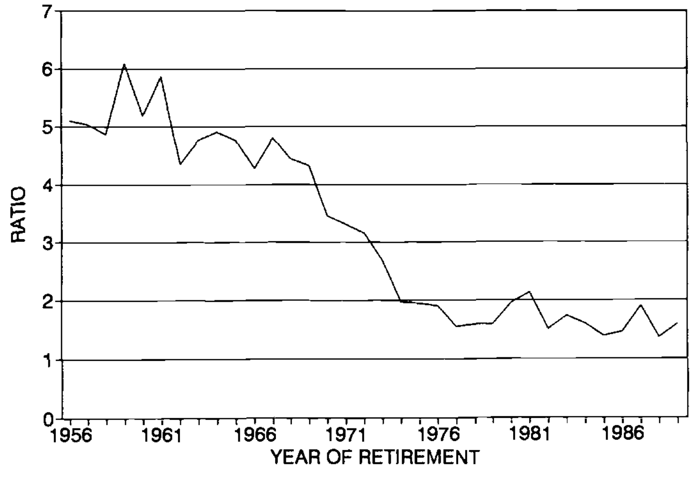

Fig. 2.3 Ratio of stock to bond accumulation for a thirty-year career

the stock strategy would have produced a monthly annuity in retirement that was over 3.5 times as large. The ratios for a forty-year career are even more dramatic, as seen in figure 2.5, with the minimum ratio of 1.95. Thus, the worst experience for a stock accumulator occurring in our data over a forty-year career was to end up with only 95 percent more pension wealth than someone investing in bonds.

It almost certainly is true that the variance in wealth at retirement is lower if one accumulates bonds rather than stocks. However, to say that bonds are a

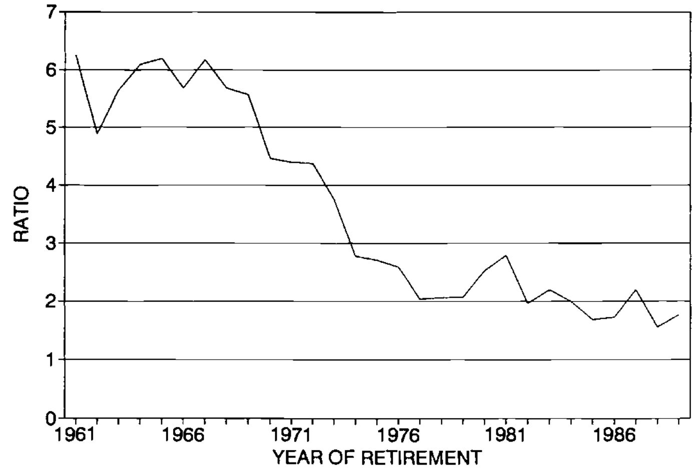

Fig. 2.4 Ratio of stock to bond accumulation for a thirty-five-year career

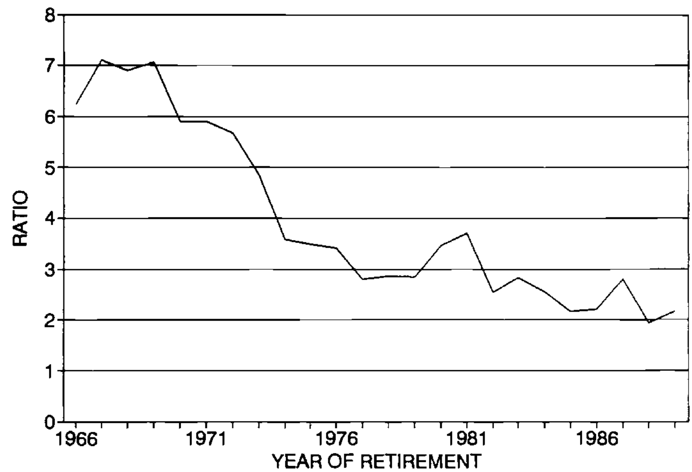

Fig. 2.5 Ratio of stock to bond accumulation for a forty-year career

safer investment vehicle seems fundamentally incorrect. The final wealth distribution with stock accumulation, even with its higher standard deviation, covers a range that is everywhere higher than the range associated with the bond distribution.

2.2.3 End of Career Strategies

The results shown in figures 2.2–2.5 assume that the stock accumulator does not deviate from a pure stock allocation strategy right up until retirement.

At the time of retirement, the wealth accumulation is evaluated and a life annuity purchased. A natural question to ask is whether one can significantly reduce the variance in the outcome by converting the accumulated stocks to bonds at multiple dates near the end of one's career. The idea, of course, is to reduce the importance of the level of the stock market on a particular day. The pension accumulator automatically does a lot of averaging by buying stock on many different dates. We now briefly examine the effect of some averaging on the sale dates.

We explore two simple end-of-career strategies designed to mitigate the risk of cashing out a 100 percent stock pension on a single day. The first involves making four transfers out of stocks, with one-quarter of the total accumulation sold at four distinct dates. We designate this investment policy as "Stock(4)." Nine months prior to retirement, an individual following a Stock(4) policy allocates all remaining pension contributions to bonds and converts one-quarter of his or her accumulated stock shares to bonds at quarterly intervals of nine, six, and three months before the retirement date. In the month of retirement, the resulting value of the diversified portfolio determines the pension accumulation associated with the Stock(4) policy. The second investment strategy examined the Stock(8) policy, eight transfers out of stocks. Following this strategy, an individual allocates all pension contributions to bonds starting twenty-one months prior to retirement. At quarterly intervals of twenty-one, eighteen, fifteen, twelve, nine, six, and three months preceding retirement, the person converts one-eighth of the stock accumulated at the twenty-one-month point into bonds. Thus, the pension value corresponding to a Stock(8) policy involves selling stocks at eight distinct dates distributed over a two-year period preceding retirement.

Table 2.1 reports the stock/bond ratios for the Stock(4) and the Stock(8) pension policies for careers of twenty-five, thirty, thirty-five, and forty years. Figures 2.6 and 2.7 plot the results comparing these two policies with the Stock(1) strategy considered above for the twenty-five- and thirty-five-year careers, respectively.

Naturally, such short-run sales strategies do not change the general shape of the gross return ratio curves. They do, however, effectively reduce the vulnerability to short-term movements in stock prices at the end of one's career. This is perhaps most clearly shown in 1961 and 1962 in table 2.1. Consider the case of a thirty-five-year career. Between 1961 and 1962, the ratio of the sell-all-stocks-at-the-end strategy to bonds falls from 6.25 to 4.88, whereas both the one- and the two-year averaging strategies do not suffer such sudden changes. The period 1986–88 offers another example. Recall that our participants begin their careers in September and retire twenty-five, thirty, thirty-five, or forty years later at the end of August. As many of us can remember, the stock market rose sharply in the first nine months of 1987, only to crash in October. For thirty-five-year careers, the sell-all-stocks-at-retirement strategy results in multiples relative to the wealth of bond accumulations of 1.72, 2.19,

Table 2.1 **Pension Savings: Ratio of Stock Plan to Bond Plan**

Retirement Year	25-Year Horizon			30-Year Horizon			35-Year Horizon			40-Year Horizon		
	Stock(1)	Stock(4)	Stock(8)	Stock(1)	Stock(4)	Stock(8)	Stock(1)	Stock(4)	Stock(8)	Stock(1)	Stock(4)	Stock(8)
1951	2.463	2.235	1.962									
1952	2.681	2.533	2.342									
1953	2.613	2.709	2.582									
1954	3.121	2.877	2.758									
1955	4.562	3.948	3.357									
1956	5.031	4.654	4.184	5.098	4.716	4.241						
1957	4.699	4.487	4.323	5.036	4.809	4.633						
1958	4.273	3.800	3.911	4.868	4.331	4.457						
1959	5.063	4.693	4.062	6.088	5.643	4.886						
1960	4.078	4.218	4.222	5.175	5.352	5.357						
1961	4.514	4.164	4.008	5.865	5.411	5.208	6.250	5.767	5.550			
1962	3.454	3.849	3.847	4.355	4.854	4.852	4.884	5.443	5.441			
1963	3.788	3.524	3.503	4.758	4.427	4.400	5.639	5.248	5.216			
1964	3.879	3.726	3.461	4.906	4.712	4.378	6.091	5.850	5.437			
1965	3.749	3.720	3.546	4.765	4.728	4.507	6.198	6.151	5.863			
1966	3.270	3.496	3.408	4.280	4.576	4.460	5.675	6.068	5.914	6.233	6.664	6.495
1967	3.483	3.172	3.121	4.799	4.371	4.300	6.168	5.617	5.525	7.107	6.473	6.367
1968	3.169	3.193	3.001	4.443	4.477	4.208	5.677	5.721	5.377	6.897	6.950	6.533
1969	3.054	3.169	3.011	4.330	4.492	4.269	5.561	5.770	5.484	7.056	7.322	6.959
1970	2.451	2.618	2.740	3.463	3.700	3.872	4.463	4.767	4.990	5.909	6.313	6.608
1971	2.417	2.428	2.420	3.323	3.339	3.327	4.391	4.412	4.397	5.905	5.935	5.914

1972	2.359	2.256	2.233	3.161	3.023	2.993	4.369	4.180	4.138	5.684	5.438	5.384
1973	2.022	2.071	2.058	2.690	2.756	2.738	3.765	3.857	3.832	4.854	4.973	4.941
1974	1.474	1.610	1.745	1.970	2.150	2.331	2.771	3.024	3.278	3.578	3.903	4.231
1975	1.450	1.369	1.426	1.944	1.836	1.913	2.710	2.560	2.666	3.496	3.303	3.439
1976	1.418	1.417	1.343	1.915	1.913	1.815	2.592	2.591	2.458	3.413	3.411	3.237
1977	1.165	1.215	1.274	1.553	1.620	1.698	2.044	2.131	2.234	2.796	2.914	3.056
1978	1.224	1.134	1.143	1.595	1.478	1.489	2.072	1.920	1.935	2.852	2.644	2.663
1979	1.254	1.157	1.115	1.593	1.470	1.417	2.068	1.909	1.840	2.850	2.630	2.536
1980	1.583	1.457	1.278	1.946	1.792	1.572	2.533	2.333	2.048	3.459	3.187	2.798
1981	1.781	1.772	1.573	2.128	2.117	1.880	2.788	2.774	2.466	3.706	3.689	3.280
1982	1.307	1.408	1.550	1.520	1.637	1.802	1.969	2.119	2.334	2.548	2.741	3.021
1983	1.522	1.379	1.367	1.736	1.573	1.558	2.205	1.999	1.979	2.822	2.559	2.532
1984	1.453	1.426	1.380	1.613	1.583	1.532	2.006	1.969	1.905	2.566	2.518	2.437
1985	1.276	1.307	1.347	1.399	1.432	1.476	1.692	1.731	1.785	2.166	2.217	2.286
1986	1.343	1.308	1.292	1.462	1.425	1.406	1.721	1.677	1.655	2.214	2.157	2.129
1987	1.763	1.487	1.379	1.907	1.609	1.493	2.194	1.852	1.719	2.795	2.359	2.190
1988	1.283	1.267	1.357	1.378	1.360	1.457	1.558	1.538	1.648	1.950	1.925	2.063
1989	1.487	1.372	1.304	1.595	1.472	1.399	1.763	1.626	1.546	2.163	1.996	1.896
Summary statistics for entire period:												
Minimum	1.165	1.134	1.115	1.378	1.360	1.399	1.558	1.538	1.546	1.950	1.925	1.896
Maximum	5.063	4.693	4.323	6.088	5.643	5.357	6.250	6.151	5.914	7.107	7.322	6.959
Average	2.640	2.555	2.460	3.196	3.123	3.039	3.580	3.538	3.471	3.959	3.926	3.875
Std dev	1.230	1.155	1.070	1.551	1.500	1.416	1.682	1.686	1.618	1.702	1.766	1.721
Summary statistics for 1980s:												
Average	1.480	1.418	1.383	1.668	1.600	1.558	2.043	1.962	1.909	2.639	2.535	2.463
Std dev	.177	.135	.096	.241	.210	.153	.373	.355	.288	.547	.523	.424

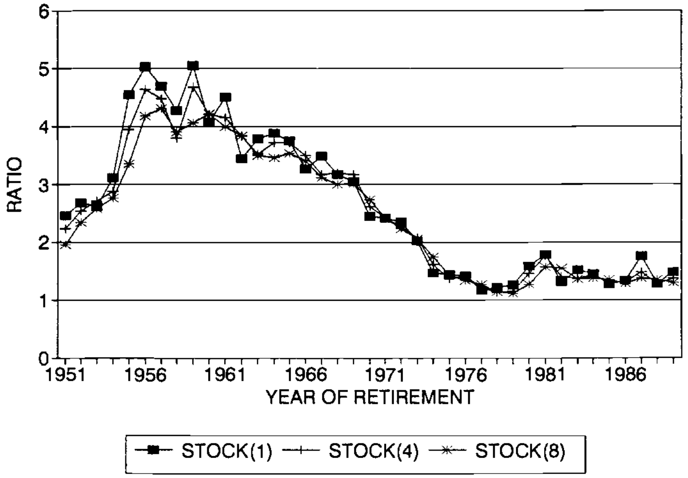

Fig. 2.6 Ratio of stock to bond accumulation for a twenty-five-year career

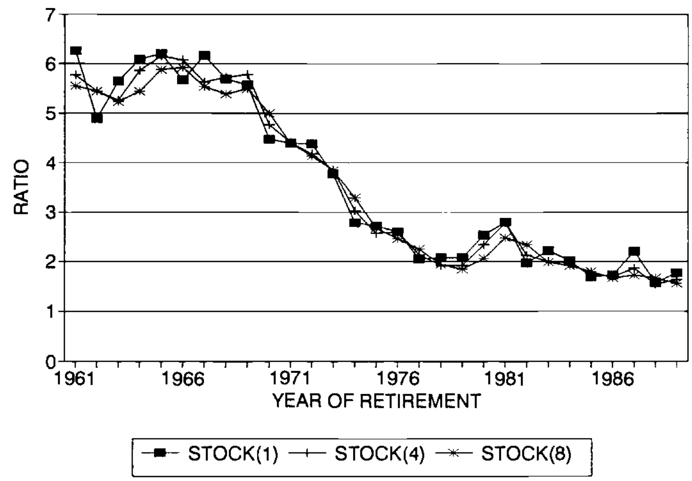

Fig. 2.7 Ratio of stock to bond accumulation for a thirty-five-year career

and 1.56 for retirements in 1986, 1987, and 1988, respectively. The stock accumulator who gradually converts to bonds over the final two years of his or her career realizes the much more stable set of ratios of 1.66, 1.72, and 1.65.

2.3 Allocation Policies of TIAA-CREF Participants

Despite the fact that stocks have outperformed bonds over long holding periods, many people saving for retirement use bonds or saving accounts as accumulation vehicles. The same is true for many other investors with presumably long horizons such as universities and foundations. For the purposes of this paper, we are most interested in the accumulation choices of professors for their retirement annuities.

TIAA-CREF generously shared some information about the allocation choices of its participants. The percentage of participants with various allocational choices are shown in figure 2.8 for the period 1969–87. These figures are for the basic TIAA-CREF retirement annuities accumulation plans and not for supplemental retirement annuities. It should be noted that CREF was not instituted until July 1952. Between the time of its inception and 31 December 1966, every contribution to CREF had to be accompanied by a contribution of at least as much to TIAA. Beginning in 1967, the premium allocation rules were changed to permit the payment of up to 75 percent of total retirement plan contributions to CREF. The rules were further changed on 1 July 1971 to provide complete flexibility, permitting the allocation of premiums between TIAA and CREF in any proportion, including 100 percent to either company.

Figure 2.8 shows that almost half of TIAA-CREF participants allocate their premiums on a fifty-fifty basis. This has been true throughout the period 1969–87. Surprisingly, at least to us, the 100 percent to TIAA option has become increasingly popular through time (being chosen by 22–24 percent in the 1980s), as has the 75 percent TIAA–25 percent CREF option (being chosen by 13–14 percent in the 1980s). The 100 percent CREF choice has been made by only about 3 percent of participants ever since this first became an option in 1971.

We have been able to obtain only a little information on the allocational choices by participants of different ages. In figure 2.9, we show the alloca-

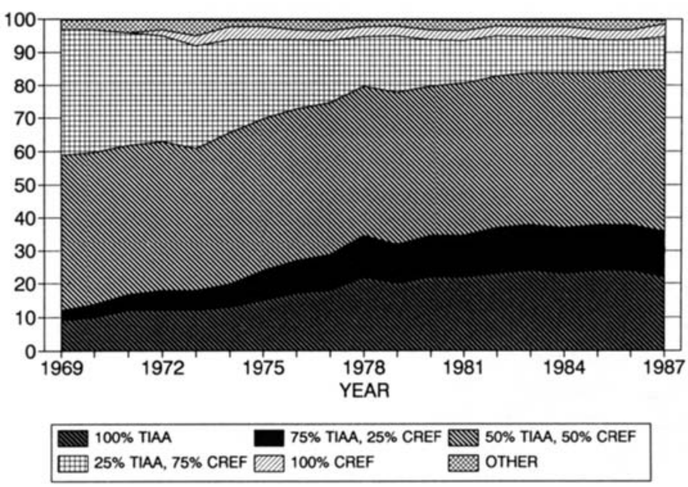

Fig. 2.8 Percentages of TIAA-CREF participants with indicated portfolio allocations

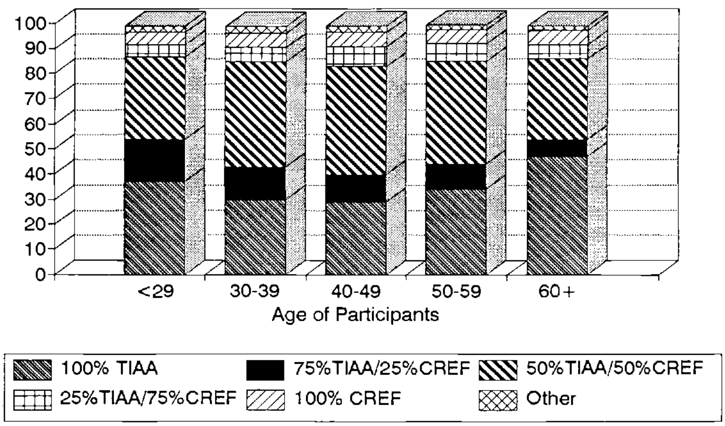

Fig. 2.9 Distribution of new supplemental retirement annuity participants by allocation choice and age

tional choices by age of new supplemental retirement annuity participants in 1984. Roughly 80 percent of the people who signed up for supplemental retirement annuity accounts choose to allocate 50 percent or less to stocks at all ages. One hundred percent stocks is not a common choice at any age. While it is true that more of the over 60 age group allocate all their funds to TIAA, our general conclusion from figure 2.9 is that there are no great differences in allocation by age.

2.4 Concluding Remarks

All the material presented in the paper has been from the point of view of a participant in a defined contribution pension system. However, we think that it is applicable to a wider class of problems, including the funding of defined benefit retirement plans by corporations. The findings simply say that systematic contributions proportional to earnings over a career have always led to more wealth at the time of retirement if the investments are in stocks rather than bonds. This information seems completely relevant to an employer who has promised retirement benefits based on final salary and years of service. The defined benefits can be funded with smaller cash contributions owing to the higher rates of return earned on stocks over long horizons.

As we have already stated, we find the results of this paper to be striking. Not only has an all stocks strategy always bested an all bonds one for all careers exceeding twenty-five years, but it has also always yielded more than the popular fifty-fifty allocation or any other constant mix of stock and bond purchases. While it is impossible to predict the likelihood that this dominance will continue, we find the evidence favoring stocks for long horizons overwhelming.

To answer the first question usually asked of us, Yes, we are allocating 100 percent of our pension contributions to stocks.

References

Fischer, Stanley, 1983. Investing for the Short and the Long Term. In *Financial Aspects of the United States Pension System,* ed. Zvi Bodie and John B. Shoven. Chicago: University of Chicago Press.

Ibbotson Associates, Inc. 1990. *Stocks, Bonds, Bills and Inflation: 1990 Yearbook.* Chicago.

MaCurdy, Thomas E., and John B. Shoven. 1990. Stock and Bond Returns: The Long and the Short of It. Stanford University. Manuscript.

Merton, Robert, and Paul A. Samuelson. 1974. Fallacy of the Log-Normal Approximation to Optimal Portfolio Decision-Making over Many Periods. *Journal of Financial Economics* 1:67–94.

Comment Jonathan S. Skinner

One finds many significant regression coefficients in empirical studies, but few empirical facts. By "empirical facts" I mean results unaffected by model specification or estimation technique—in short, findings about which all economists agree. In their paper, Thomas E. MaCurdy and John B. Shoven present a particularly interesting fact; in every twenty-five year period since 1926, the stock market has outperformed bonds. As they show, accumulated wealth from an all stock pension was as much as four times the accumulated wealth from an all bond pension.

If their finding holds true generally, it has far-reaching implications. First, as they note, the theoretical debate over the "equity premium" puzzle becomes irrelevant since there is no degree of risk aversion that would lead one to hold bonds if stocks outperform bonds in every state of the world. Second, the result implies a massive, and highly costly, degree of ignorance and irrationality on the part of investors. Their result using data on TIAA-CREF pension holdings is particularly strong since one cannot blame a short-sighted portfolio manager for choosing bonds over stocks; each individual employee is free to choose his or her own portfolio allocation of stocks and bonds. The authors' finding therefore casts doubt on investor rationality—the bedrock assumption of the theory of finance.

One could of course appeal to a portfolio explanation for why TIAA-CREF enrollees hold bonds. For example, suppose an enrollee finances 90 percent

Jonathan S. Skinner is associate professor of economics at the University of Virginia and a research associate of the National Bureau of Economic Research.

of his or her house with a fixed-rate mortgage. Given the substantial year-to-year variation in housing prices,[1] the homeowner can reduce his or her overall risk exposure by matching the long-term mortgage liabilities with long-term bonds. In this view, holding bonds in a pension fund may not make sense in isolation, but it does make sense in combination with the other household assets.

There are two problems with this explanation for holding bonds. The first is that the price of (long-term) bonds is negatively correlated with the nominal interest rate. If high nominal rates also depress housing prices, then buying long-term bonds could potentially increase overall risk. The second is that, if stocks dominate bonds in every state of the world, there is *no* combination of risk aversion or risk correlation that would imply that bonds should be held.[2] No matter what happens in the housing market, the risk-averse homeowner is still better off holding stocks over bonds.

The key question is whether the sixty-three years of data from 1926 to 1989 can allow one to conclude that stocks will dominate bonds in "all states of the world." The problem with calculating long-term yields of stocks versus bonds is that there are not really sixty-three independent observations since the return between, say, 1926 and 1951 obviously will be highly correlated with the return between 1927 and 1952. There are less than three twenty-five-year periods in the authors' data set, so we may reasonably conclude that the relevant degrees of freedom for making their inference are between three and sixty-three. Hence, standard errors on past stock and bond returns as applied to future returns may be quite generous given the long investment horizons involved.

One strategy to test the strength of their result is to extend the period of analysis. Stock and bond data exist from 1872, allowing one to roughly double the size of the sample. Using data on real stock yields calculated by Robert Shiller of Yale University and railroad bond yields from the 1949 *Historical Statistical Abstract,* I calculated the relative return on stocks and railroad bonds since 1900, assuming that the individual placed $1.00 each year in the "pension" fund. I calculated that, for every twenty-five-year period since 1900, the "pension" in stocks outperformed the same investment in bonds, even had the investor cashed out the stock portfolio at the depth of the Great Depression. If the investor had held off until 1935, the twenty-five-year stock investment would have beaten the bond investment by nearly three to one. So, in this respect, MaCurdy and Shoven's argument is even stronger—there is no twenty-five-year period since 1900 during which stocks did not outperform bonds.

The story is different between 1872 and 1899. As Snowden has carefully

1. See James Berkovec and Don Fullerton, "A General Equilibrium Model of Housing, Taxes, and Portfolio Choice," NBER Working Paper no. 3505 (Cambridge, Mass.: National Bureau of Economic Research, November 1990).

2. I am grateful to Tom MaCurdy for pointing this out to me.

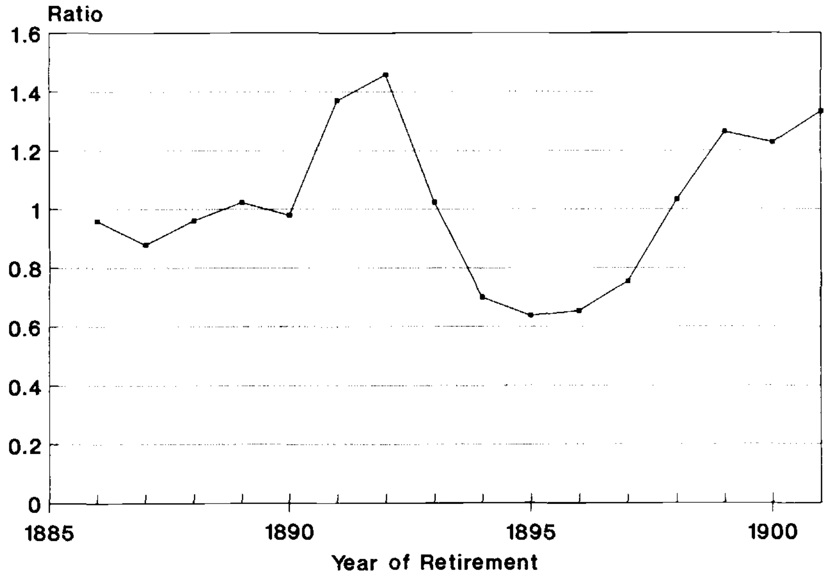

Fig. 2C.1 Ratio of stock to bond accumulation for fifteen-year holding period, 1872–1901

Source: Kenneth Snowden, "Historical Returns and Security Market Developments, 1872–1925," Working Paper no. ECO 891001 (Greensboro: University of North Carolina, October 1989).

documented, bonds generally outperformed stocks during this period.[3] The real geometric mean return on stocks from 1872 to 1899 was 7.25, while the corresponding return on high-grade rail bonds was 8.20.[4] In part, the higher return was a consequence of unexpected deflation during the period and the (unrealized) possibility that the bonds would be repayed under an inflated silver standard. Furthermore, both the bond and the stock market were dominated by railroad company issues.

A similar exercise to that performed by MaCurdy and Shoven is shown for the period 1872–1901 in figure 2C.1. Because the period of analysis is so short, I focused on fifteen-year periods in which the investor contributes $1.00 per year along with the accumulated proceeds from previous years. As in MaCurdy and Shoven's paper, the ratio calculated is the accumulated stock wealth divided by accumulated bond wealth. During half the retirement dates between 1886 and 1901, the bond portfolio outperformed the stock portfolio.

3. Kenneth Snowden, "Historical Returns and Security Market Development, 1872–1925," Working Paper no. ECO 891001 (Greensboro: University of North Carolina, October 1989).

4. While railroad bonds dominated the bond market during this period, the geometric mean returns on government bonds (5.61) and commercial paper (6.65) were lower than the return on stocks (see ibid.).

And, as noted above, bonds outperformed stocks during the entire period 1872–99. This historical excursion therefore leads to a modification of the authors' statement that "there has never been a span of time for which this strategy [of holding a portfolio with bonds] would be profitable." The amended version is that, in the 117 years since 1872, there was one twenty-eight-year period (and many overlapping fifteen-year periods) during which railroad bonds outperformed stocks. This reversal does not deflect the main thrust of MaCurdy and Shoven's result since, even when bonds did outperform stocks, it was not by a large amount. But if there is any positive probability that bonds will yield a higher return than stocks, then investors can be rational, if astonishingly risk averse, to hold bonds.