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3 Pension Funding and Saving

B. Douglas Bernheim and John B. Shoven

The private saving rate in the United States in 1984 has to be considered disappointing. After the enactment of a large number of policies to make investment/saving more rewarding (such as liberalized Individual Retirement Accounts and Keogh Plans, the special tax treatment of some reinvested dividends, capital gains taxes which have been reduced twice in the past six years, and certainly increased investment incentives at the corporate level), the preliminary Bureau of Economic Analysis (BEA) estimate for the 1984 personal saving rate is 6.1 percent of disposable personal income. This is lower than the average personal saving rate in the 1970s of 7.3 percent, and only imperceptably better than the 6.0 percent of the first four years of this decade. With all of these incentives, plus a robust economy and record high real interest rates, why was the personal saving rate so low? We are not going to attempt to answer this general question here. Rather, we suggest that personal saving needs to be examined in a disaggregated manner. Some of the policies just mentioned do not really provide incentives to save at the margin, but only serve to channel the existing quantity of saving

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or wealth through particular vehicles. Undoubtedly, this accounts for at least some of the apparent sluggishness in private saving.

Our topic, however, is the behavior of personal saving which results from the funding of pension plans. In this country, most covered workers participate in defined benefit plans, where the promised pension annuity is based on years of service and level of compensation, and not directly on the funding status of the plan or the return on the investments which have been previously acquired to fund the plan. However, while the worker may be able to separate his or her accumulation of pension rights or wealth from the funding of the plan, it is the aggregate funding contributions less outlays (i.e., benefits) which constitute a component of personal saving, and which generate loanable funds to finance investment or government deficits. Thus, the structure of defined benefit plans may produce a divergence between the apparent saving of workers through the accumulation of pension rights and the actual creation of loanable funds through net contributions to pension plan reserves.

This can be an important phenomenon if only because pension funds are so large relative to financial markets and because pension contributions constitute such a large fraction of personal saving. Also, net corporate pension contributions fell sharply in 1984. They amounted to 4.02 percent of personal disposable income in 1984, down from 6.02 percent in 1982. Thus, the decline in pension funding was large enough to be responsible for the disappointing level of aggregate personal saving. Indeed, these figures raise the possibility that, had pension contributions remained at their 1982 level, the personal saving rate might have risen by as much as 2 percent, to perhaps 8 percent in 1984. Had this indeed occurred, various policies designed to stimulate saving might have been judged more successful.

To understand why corporate pension contributions dropped so significantly in 1984, one simply has to examine the defined benefit pension contract from the firm's point of view. The liability of the firm is to pay for retirement annuities for its vested workers. To calculate the present value of this obligation, the firm typically predicts the magnitude of those annuities (making some assumptions regarding wage growth until retirement, labor turnover, etc.) and then discounts the future obligation to the present using an assumed interest rate. The resulting present value of liabilities is then compared to the value of the assets in the plan to arrive at the net unfunded liability. By law, contributions are related to the unfunded liability of the plan, although the companies have substantial discretion both as to the speed with which unfunded liabilities are amortized and in the assumptions which are made in arriving at the value of unfunded liabilities. However, the key point is that from the company's point of view, the funding of pension liabilities is a target—the higher the earnings of the assets funding the plan, the lower the contributions needed to meet the obligations. If the assets earn more than the assumed discount rate used to value the liabilities (or if the assumed interest rate is raised or the assumed rate of growth of wages is lowered), the unfunded liability will be reduced (or, more relevantly for many companies, become negative) and the contributions will tend to decline. In the not-so-rare case (in 1984) of an overfunded plan, the law may force a reduction or an elimination of contributions. The very factors which have been hailed as the economic achievements of the past few years (e.g., a rising stock market and a reduction in wage inflation), combined with those high real interest rates which may encourage other kinds of saving, are the primary reasons behind the reduction in the number of underfunded plans and the sharp drop in pension contributions. As with the classic target saving examples, defined benefit pension contributions have a negative elasticity with respect to (real) interest rates. With pension contributions so large a part of total personal saving, the negative elasticity of this component may significantly offset the positive responsiveness of other components of saving. This effect has not been explicitly considered in previous studies of the interest elasticity of private saving (see, e.g., Boskin 1978, Howrey and Hymans 1978, and Summers 1981).

We have not investigated potential offsets to reductions pension contributions. Clearly, resources diverted from pension funds will be employed elsewhere. Indeed, if investors penetrate all corporate and governmental veils, aggregate saving should be unaffected. While these issues no doubt merit careful consideration, they are far too complex to treat within the context of the current study. It is therefore appropriate to emphasize that the negative elasticity of contributions to a defined benefit pension plan is not the result of intertemporal optimization on the part of either the firm or the workers; it is a purely mechanical response inherent in the funding rules for these types of plans.

In section 3.1, some empirical information is given regarding pension contributions, unfunded liabilities, assumed interest rates, and recent developments in pension funding. Then in section 3.2, we present our target saving model of pension funding and derive the elasticity of contributions to changes in interest rates. Section 3.3 presents our econometric estimates of aggregate contributions as a function of lagged interest rates, inflation rates, the pattern of wage growth, and the behavior of the stock market. We summarize our findings in section 3.4.

3.1 Institutional Considerations

As table 3.1 shows, most pension plans (72 percent of them) are defined contribution. However, the defined contribution plans are typ-

Table 3.1 Basic Characteristics of Private Pension Plans, By Type of Plan, 1978

	Defined Benefit	Defined Contribution	Total
Plans (#)	139,340 (28.1%)	356,505 (71.9%)	495,845
Participants	36.1 mil (68.9%)	16.3 mil (31.1%)	52.4 mil
Assets (market value)	$272.7 bil (72.3%)	$104.5 bil (27.7%)	$377.2 bil

SOURCE: U.S. Department of Labor (1983).

ically small and often supplement a defined benefit plan (a notable exception being TIAA-CREF, which is the largest pension plan in the United States). In terms of participants or assets, defined benefit plans dominate with about 70 percent of the total. To gain some appreciation of the aggregate size of private pension plans, note that the 52.4 million covered workers represent about 53 percent of all civilian employees in 1978, and the $377.2 billion in private pension assets amounts to 51 percent of the equity holdings of households in 1978. If government pensions were included, the Federal Reserve Flow of Fund figures show 1978 pension assets at $593 billion. In comparison, households held $741 billion of corporate equity.

Table 3.2 shows the number of new plans qualified and terminated by type for the years 1974–84. Prior to this period, defined benefit plans had been growing more rapidly. In every year from 1956 to 1974, the number of new defined benefit plans exceeded the number of new defined contribution plans. However, since the 1974 Employee Retirement Income Security Act (ERISA) the pattern has been reversed. In the first three quarters of 1984, the number of defined benefit terminations was at a record level and the net growth in defined benefit plans was running at a 2 percent yearly rate. The changes in the relative popularity of defined benefit versus defined contribution plans is almost certainly due to the funding, vesting, and insurance requirements of ERISA for defined benefit plans.

There are two sources of data regarding aggregate private pension contributions and benefits, the Flow of Funds data of the Federal Reserve System and the U.S. Commerce Department's National Income and Product Account (NIPA) information. As with total saving figures, the two sources do not agree particularly well on the numbers. The time series on net acquisitions of financial assets by pension funds from the Flow of Funds information is shown in table 3.3 for 1948 through 1984. The numbers for 1984 show a fairly drastic decline. The 1984 figure for private pensions alone was more than $30 billion less than

Table 3.2 Number and Growth of Pension Plans by Type

Year	Defined Benefit Qualified	Defined Benefit Terminated	Defined Benefit Qualified Minus Terminated	Defined Benefit Plans: Total Number	Defined Benefit Plans: Growth Rate
1974	—	—	—	128,255	—
1975	6,235	2,953	3,282	131,537	2.6%
1976	4,475	5,860	(1,385)	130,152	−1.1
1977	6,953	5,337	1,616	131,768	1.2
1978	9,728	4,625	5,103	139,340	5.7
1979	15,755	3,267	12,488	157,639	13.1
1980	18,849	4,297	14,552	179,424	13.8
1981	23,789	4,536	19,253	198,677	10.7
1982	28,189	5,043	23,146	221,823	11.7
1983	22,130	7,230	14,900	236,723	6.7
84Q1–Q3	11,053	7,566	3,487	—	—

Year	Defined Contribution Qualified	Defined Contribution Terminated	Defined Contribution Qualified Minus Terminated	Defined Contribution Plans: Total Number	Defined Contribution Plans: Growth Rate
1974	—	—	—	271,655	—
1975	23,804	5,155	18,649	290,304	6.9%
1976	21,454	10,053	11,401	301,705	3.9
1977	28,463	10,478	17,985	319,690	6.0
1978	55,956	10,661	45,295	356,505	11.5
1979	41,122	7,574	33,548	381,112	6.9
1980	50,493	8,982	41,511	410,469	7.7
1981	57,748	8,906	48,842	459,311	11.9
1982	57,162	10,108	47,054	506,365	10.2
1983	42,089	11,417	30,672	537,037	6.1
84Q1–Q3	24,360	9,321	15,039		

SOURCE: Employee Benefit Research Institute, Washington, D.C.

NOTE: In 1978–80, the growth in the total number of plans does not match the number of qualified plans minus the number terminated. EBRI apparently derives these numbers from different sources and does not reconcile the totals.

for 1982. The growth rate in net acquisitions is also down, though less dramatically, for pensions managed by insurance companies and state and local government pension systems. The magnitude of the drop in net acquisitions from a trend line is comparable to the total inflow of money into IRA and Keogh accounts. Thus, the effects discussed here appear to be large relative to the saving incentives mentioned earlier. The importance of net acquisitions by pension funds relative to personal saving can be judged by comparing columns 4 and 5 of table 3.3.

Table 3.3 Net Acquisitions of Financial Assets by Pension Funds ($ billion)

Year	Private (1)	Insured (2)	State/Local (3)	TOTAL (4)	NIPA[a] Personal Saving (5)
1948	0.6	0.6	0.4	1.6	11.2
1949	0.6	0.6	0.5	1.7	7.5
1950	1.7	0.8	0.7	3.2	11.8
1951	1.1	1.0	0.8	2.9	16.0
1952	1.7	1.1	1.0	3.8	17.3
1953	1.9	1.1	1.3	4.3	18.6
1954	2.0	1.2	1.5	4.7	17.0
1955	2.3	1.3	1.3	4.9	16.3
1956	2.7	1.2	1.3	5.2	21.3
1957	3.0	1.6	1.7	6.3	22.4
1958	3.1	1.5	1.8	6.4	23.6
1959	3.7	2.0	1.9	7.6	21.1
1960	4.0	1.3	2.2	7.5	19.7
1961	3.9	1.4	2.4	7.7	23.0
1962	4.2	1.4	2.4	8.0	23.3
1963	4.3	1.7	2.6	8.6	21.9
1964	5.5	2.0	3.0	10.5	29.6
1965	5.4	2.1	3.3	10.8	33.7
1966	6.9	2.1	4.2	13.2	36.0
1967	6.6	1.5	4.1	12.2	44.3
1968	6.5	2.3	4.8	13.6	41.9
1969	6.3	3.1	5.5	14.9	40.6
1970	6.9	2.9	6.4	16.2	55.8
1971	7.1	4.6	6.6	18.3	60.6
1972	11.5	4.4	8.5	24.4	52.6
1973	14.1	5.7	9.5	29.3	79.0
1974	21.5	6.0	9.7	37.2	85.1
1975	23.1	8.7	11.3	43.1	94.3
1976	18.9	15.0	12.9	46.8	82.5
1977	23.1	16.8	15.9	55.8	78.0
1978	28.8	19.1	20.7	68.6	89.4
1979	40.8	19.4	16.2	76.4	96.7
1980	48.9	22.3	26.5	97.7	110.2
1981	37.6	29.5	31.0	98.1	137.4
1982	54.3	39.7	37.3	131.3	136.0
1983	47.3	40.2	44.5	132.0	118.1
1984	23.5	40.8	39.3	103.6	—

SOURCE: *Flow of Funds*, Federal Reserve System.
[a]National Income and Product Account, U.S. Commerce Department.

The NIPA data for private pensions, which we use in the empirical work of section 3.2, is shown in columns 1 and 2 of table 3.4. The NIPA provides separate information on contributions and benefits paid, and we generally consider it to be more reliable than the Flow of Funds numbers. The NIPA contribution figures are based on business tax

Table 3.4 NIPA Data on Private Pension Contributions, Benefits, and Reversions ($ billion)

Year	Private Pension Contributions[a]	Private Pension Benefits Paid[a]	Reversions[b]
1947	—	—	0
1948	1.196	—	0
1949	1.262	—	0
1950	1.713	0.370	0
1951	2.262	0.450	0
1952	2.543	0.520	0
1953	2.861	0.620	0
1954	2.903	0.710	0
1955	3.377	0.850	0
1956	3.757	1.000	0
1957	4.153	1.140	0
1958	4.134	1.290	0
1959	4.771	1.540	0
1960	4.866	1.720	0
1961	4.966	1.970	0
1962	5.442	2.330	0
1963	5.760	2.590	0
1964	6.591	2.990	0
1965	7.646	3.520	0
1966	8.675	4.190	0
1967	9.456	4.790	0
1968	10.717	5.530	0
1969	11.823	6.450	0
1970	13.050	7.360	0
1971	15.108	8.597	0
1972	17.903	10.015	0
1973	20.934	11.235	0
1974	24.218	12.970	0
1975	28.253	14.855	0
1976	32.972	16.651	0
1977	38.764	18.761	0
1978	44.869	21.940	0
1979	48.903	27.272	0
1980	54.242	31.258	0.014
1981	55.831	37.634	0.157
1982	60.387	45.585	0.396
1983	64.821	—	1.558
1984	—	—	1.172

[a]NIPA, "Other Labor Income by Industry and Type."
[b]Pension Benefits Guarantee Corporation, Washington, D.C.

return information, while their numbers for benefits paid are based on individual tax returns netted out for government pensions. This information is not yet available for 1984, so our estimations in section 3.3 will not use the dramatic developments of that year. Column 3 of table 3.4 contains information from the Pension Benefits Guarantee Corporation on reversions. Reversions have received a lot of attention recently, partly because a few large publicly held companies have terminated their pension plans in this manner. A pension plan reversion can occur when the plan becomes overfunded. The existing plan is terminated and a new plan (usually a defined contribution plan) is adopted (often with the old obligations covered by insurance company annuities). The excess of the value of the plan assets over the cost of the annuities may revert to the company. The whole procedure is made possible because assets have previously earned more than the assumed interest rate. The case which received the most attention was the Great Atlantic and Pacific Tea Co. which recouped $272.9 million out of its $355.1 million pension fund with a reversion completed in 1984. The figures in table 3.4 show that the aggregate quantity of reversions is still relatively small, but the growth rate in this practice has been phenomenal. The reversions already pending in January for 1985 amounted to $1.824 billion, and the figure is likely to go much higher. Clearly, reversions reinforce the downward pressure on saving created by the lower net contributions. Reversions and the lower contributions actually have the same underlying cause. In both cases, assets have been earning far in excess of assumed discount rates, resulting in many pension funds which are massively overfunded if market rates were used to discount the pension obligation. Reversions amount to the company recognizing this profit suddenly, while most ongoing plans simply reduce contributions over a long period of time.

Pension plans have been slow to adjust their assumed interest rates toward market rates. The mean assumed interest rate for plans with more than 1000 participants has climbed from 6 percent in 1980 to 7.2 percent in 1984, as shown in table 3.5. However, this growth in the assumed interest rate has been matched by increases in the assumed salary growth for the 70 percent of defined benefit plans which project wage increase in determining liabilities. In fact, the spread between the interest assumption and the wage growth assumption has narrowed

Table 3.5 **Mean Assumed Interest Rates for Plans with over 1000 Participants**

1976	5.5 percent
1978	5.8 percent
1980	6.0 percent
1981	6.3 percent
1982	6.8 percent
1983	7.0 percent
1984	7.2 percent

SOURCE: The Wyatt Company (1985).

slightly in the past eight years. Since 1976, the average spread has decreased from 2.3 percent to 1.5 percent.

The adjustment toward market interest rates may be occurring somewhat faster than the previous numbers indicate, however. A strategy termed "immunization" or "dedication" has become increasingly popular. A portfolio is said to be immunized when the cash flow (interest plus principle) generated by the assets matches the cash flow of the pension liabilities. Dedication is a less precise matching strategy where the average duration of the assets matches the duration of the liabilities. By structuring the portfolio in these ways, plan managers are protecting themselves from interest rate risk. A change to a dedicated or immunized portfolio amounts to suddenly changing the assumed interest rate to the market rate. In the suddenness of the adjustment, the adoption of these strategies is similar to a reversion. Total dedications and immunizations amounted to at least $10 billion in 1984, with Ameritech leading the pack with a $2.4 billion asset dedication. Chrysler participated in a big way with a $1.1 billion immunization. The annualized yield on Chrysler's immunized portfolio exceeds 14 percent. While aggregate numbers are difficult to come up with, this phenomenon appears to be somewhat larger than reversions, and certainly it amounts to an added factor dampening pension contributions. One final example of the effect of dedication on contributions is given by the Western Conference of the Teamsters Union. The union is in the process of adopting the strategy for its entire $5.1 billion portfolio. In 1984 it placed $1.777 billion in dedicated bond portfolios yielding over 12 percent. When it completes the dedication process, the entire $1 billion of "unfunded liability" of its pension system will have been eliminated without further contributions. Basically, by structuring the portfolios in this manner, actuaries are willing to raise the assumed interest rate to the market rate, thus dramatically lowering both unfunded liabilities and contributions.

The effects of high market interest rates and high stock market returns can be seen by examining the funding status of pension plans. Table 3.6 shows the distribution of the ratio of assets to present value of accrued vested liabilities at the end of 1983 for the Fortune 500 industrials. Even using the companies' interest rate assumptions, fully 88 percent were fully funded and 34 percent were more than 50 percent overfunded. If the calculations are redone with a common 10 percent interest rate, 94 percent are fully funded and almost 70 percent are more than 50 percent overfunded. The overfunding would be even more massive at true market interest rates which ranged between 13 and 15 percent. The figures of table 3.6 were requested by the Financial Accounting Standards Board (FASB), Statement no. 36, and did not permit the use of salary growth projections. Many companies do make these

Table 3.6 Distribution of Vested Funded Ratios for the Fortune 500 Industrials for 1983

	Percent of Companies			
	With Assumed Interest Rates		With 10% Interest Rate	
Funded Ratio	%	Accumulated %	%	Accumulated %
200% and above	7	7	30	30
175%–199%	8	15	18	48
150%–174%	19	34	21	69
140%–149%	10	44	6	75
130%–139%	11	55	7	82
120%–129%	13	68	5	87
110%–119%	10	78	4	91
100%–109%	10	88	3	94
90%– 99%	3	91	2	96
80%– 89%	4	95	2	98
70%– 79%	2	97	1	99
60%– 69%	1	98	1	100
50%– 59%	1	99	0	100
Under 50%	1	100	0	100

SOURCE: Hewitt Associates (1984).

projections to calculate their unfunded liabilities and to determine contributions. Regardless of method, however, the funding levels of plans have dramatically improved in the last few years. Again, on the FASB no-projection basis, the percent of the Fortune 500 industrials whose assets are at least as much as accrued-vested benefits (with their discount rates) has climbed from 58 percent in 1980 to 69 percent in 1981, 78 percent in 1982, and 88 percent in 1983. The figures are not available yet for 1984, but a further gain in funding relative to liabilities is most likely.

3.2 Theoretical Considerations

In section 3.1, we described the institutional factors which largely govern the response of pension fund accumulation to changes in interest rates. Our next objective is to quantify these effects using a simple model of defined-benefit pension plans, for which we compute theoretical long-run and short-run interest elasticities. Although these calculations provide us with a sense for magnitudes, certain critical parameters are not institutionally determined. In order to refine our estimates of these interest elasticities, as well as to confirm the predictions of our theoretical analysis, we devote section 3.3 to an empirical analysis of pension fund accumulation.

Consider a firm which, in period t, accrues new pension liabilities

$$L^t = (L^t_{t+1}, \ldots, L^t_{t+T}),$$

where $L^t_{t+\tau}$ is the liability accrued in period t to be paid in period $t + \tau$. The notion of "accrual" used here corresponds to whatever actuarial convention is employed by firms under ERISA regulations. Let λ^t denote its stream of previously accrued liabilities:

$$\lambda^t = (\lambda^t_t, \lambda^t_{t+1}, \ldots, \lambda^t_{t+T}).$$

Here, $\lambda^t_{t+\tau}$ represents liabilities to be paid in period $t + \tau$, which have been recognized by period t. These streams are related as follows:

$$\lambda^t_{t+\tau} = \sum_{n=t+\tau-T}^{t-1} L^n_{t+\tau}, \ \tau = 0, \ldots, T - 1 \ ; \ \lambda^t_{t+T} = 0.$$

Note that λ^t_t ($\tau = 0$) represents the value of pension benefits which the firm must pay out in period t. Throughout, we will take the stream of real liabilities as given.

In what follows, for any stream $X = (X_t, X_{t+1}, \ldots, X_{t+S})$, we will denote the present discounted value of X by

$$V_t(X) = \sum_{\tau=0}^{S} X_{t+\tau}/(1 + i)^\tau \quad ,$$

where i is the nominal interest rate. We will also denote the "duration" of X by

$$D_t(X) = \sum_{\tau=0}^{S} \tau \left[\frac{X_{t+\tau}/(1 + i)^\tau}{V_t(X)}\right] \quad .$$

The duration of X measures its average maturity. We will use $\epsilon_i[V_t(X)]$ to denote the interest elasticity of $V_t(X)$. The following result will prove useful:

$$\begin{aligned}\epsilon_i[V_t(X)] &= \frac{1 + i}{V_t(X)} \frac{dV_t(X)}{di} \\ &= -\left[\frac{1 + i}{V_t(X)}\right]\sum_{\tau=0}^{S} \tau X_{t+\tau}/(1 + i)^{\tau+1} \\ &= - D_t(X)\end{aligned}$$

Thus, the elasticity with respect to the interest rate of the value of a nominal stream of payments is equal to the negative of the stream's duration. We note that this is not the conventional interest elasticity expression, but it is approximately the percentage change in value per *percentage point* change in the interest rate (precisely, it is the percentage change in value relative to the percentage change in $1 + i$). This, of course, is quite a different figure from the traditional elasticity, which would in this case be the percentage change in value relative to the percentage change in the interest rate. As an example of the difference, consider a consol which pays \$1 per period as a perpetuity. Its present value is $1/i$, and the traditional elasticity of its value with respect to the interest rate is -1. The interest elasticity that we have just defined, which we should perhaps term the *sensitivity* or *responsiveness* of value to interest rate changes, is $-1/i$. We have chosen to express our elasticities in this manner only because we find it more natural to think about a 1 percentage point move in the interest rate from, say, 4 percent to 5 percent rather than a 1 percent change from, say, 4.00 percent to 4.04 percent.

In this paper, we will be concerned with changes in the *real* interest rate. To avoid unnecessary notation, we simply denote every stream in real dollars and discount by the real rate, r. Subsections 3.2.1 and 3.2.2 consider long-run and short-run effects, respectively.

3.2.1 Long-Run Effects of Changes in the Real Interest Rate

ERISA regulations permit temporary underfunding and overfunding of pension plans, but they require firms to fund their liabilities fully in the long run. It is therefore natural to begin our investigation by considering steady states, which are characterized by constant interest rates (as well as other exogenous variables), and full funding of current liabilities. Thus, at time t, pension assets (A_t) are given by

$$A_t = V_t(\lambda^t) \quad . \tag{1}$$

We will assume that, in the long run, the liability profile grows at a constant rate, g, by which we mean the following:

$$L^t_{t+\tau} = (1 + g)^{t-t'} L^{t'}_{t'+\tau} \quad .$$

Note that this assumption places no constraint on the shape of the new liability profile L^t, although it does imply that benefits paid, λ^t_t, and the value of discounted liabilities, $V_t(\lambda^t)$, will grow at the rate g. Thus, pension assets, A_t, will also grow at this rate.

In steady state, pension assets always cover accrued liabilities *exactly*. Thus, to maintain full funding, current contributions, C_t, must equal the value of new accrued liabilities:

$$C_t = V_t(L^t) \quad . \tag{2}$$

Between equations (1) and (2), we may analyze the steady-state effects of a change in the real interest rate on pension fund contributions and total capital accumulation, given a fixed liability profile.

The assumption of a fixed liability profile is essential to our calculations. Yet, ordinarily, we would expect changes in the rate of interest to be accompanied by changes in wage rates and perhaps in levels of employment. It is, therefore, important to clarify the nature of our exercise. Ultimately, one is interested in the general equilibrium effects of any particular policy change. However, these effects are determined by partial equilibrium responses. The interest elasticity of saving, defined as the response of saving to a change in the interest rate given fixed values of other variables (such as wage rates and employment levels), often appears as a critical parameter in policy analyses. Consequently, many authors have attempted to measure personal saving elasticities. Our analysis is in the spirit of these earlier studies.

From equation (1), we see immediately that the long-run interest elasticity of pension fund assets is

$$\epsilon_r(A_t) = - D_t(\lambda^t) \quad ,$$

where, again, this elasticity is the percentage change in the value of assets for a 1 percentage point change in interest rates. While we have no data on the duration of current pension fund liabilities, it is instructive to make some rough calculations based on hypothetical values. It seems reasonable to believe that the duration of outstanding liabilities is in the neighborhood of 15 years. If so, a 1 percentage point increase in the real interest rate would *depress* the long-run value of pension fund assets by 15 percent. Given the current size of pension funds, this translates into roughly \$100 billion of capital assets.

A similar calculation for yearly contributions reveals that

$$\epsilon_r(C_t) = - D_t(L^t) \quad .$$

Here we clearly see the "target saving" aspect of defined benefit pension programs: if all saving takes place to fund an expenditure in the following period $[D_t(L^t) = 1]$, then the elasticity of saving is -1. Longer maturity structures will amplify the effect of interest rate changes. Again, we have no direct evidence concerning the magnitude of $D_t(L^t)$. However, we can make suggestive calculations based on hypothetical values. It seems reasonable to believe that the duration of newly accrued liabilities is in the neighborhood of 30 years. If so, a 1 percentage point increase in the real interest rate would *depress* the long-run value of pension fund contributions by 30 percent. Given current magnitudes, this translates into roughly \$25 billion.

Of course, pension funds pay out significant benefits and earn interest on existing assets. Thus, net pension saving in year t, N_t, is given by

$$N_t = C_t + rA_t - B_t$$

(where benefits paid, $B_t = \lambda_t^t$). Our previous calculations reveal how C_t changes with the real interest rate. By assumption, B_t is invariant. For the remaining term (reinvested interest on assets), we observe that our elasticity measure for rA_t is

$$\epsilon_r(rA_t) = \frac{1}{r} - D_t(\lambda^t) \quad .$$

Taking $r = 0.025$, and $D_t(\lambda^t) = 15$ as before, yields an elasticity of 25. If, in addition, A_t = \$650 billion, then a 1 percentage point increase in the real interest rate will, through this channel, bring forth approximately \$4 billion in pension fund saving.

It is useful to summarize the changes in net pension saving relative to total personal saving, S_t. Suppose that $A_t/S_t = 4$, $A_t/C_t = 8$, $A_t/B_t = 16$, and $r = 0.02$ (these magnitudes correspond roughly to historical averages). Then

$$\frac{1 + r}{S_t}\frac{dN_t}{dr} = \frac{C_t}{S_t}\epsilon_r(C_t) + \frac{rA_t}{S_t}\epsilon_r(rA_t)$$

$$= .5\,\epsilon_r(C_t) + .1\,\epsilon_r(rA_t) \quad .$$

Using our previous values for stream durations,

$$-.5(30) + .1(25) = -12.5 \quad .$$

Thus, in the long run, a 1 percentage point increase in the real interest rate may depress net pension fund saving by 12.5 percent of total personal saving.

If investors perfectly pierce the corporate veil, then adjustments in private portfolios will completely offset these changes. However, if the offset does not occur or is only partial, the impact on private saving elasticities may be substantial. Of course, partial offsets are much more plausible in the short run than in the long run. In addition, unexpected changes in interest rates are likely to induce short-run capital gains or losses on existing assets, leading to short-run pension fund imbalances. It is therefore essential to consider the short-run response of pension funds to interest rate changes.

3.2.2 Short-Run Effects of Changes in the Real Interest Rate

Consider a pension fund with certain assets and liabilities. Suppose that there is an unanticipated change in the real interest rate during some period. How does the accumulation of pension fund assets respond in each successive period? It is useful to divide this question into two parts. First, how would the magnitude of unfunded liabilities respond to a change in interest rates, if the full impact of this change was recognized immediately? Second, how do recognition and response lags determine the timing of compensating adjustments? These questions will be tackled in order.

The response of net unfunded liabilities to a change in the interest rate can be divided into two parts: changes in assets and changes in liabilities. First, consider liabilities. The total value of outstanding liabilities is given by $V_t(\lambda^t)$. We have already calculated that

$$\epsilon_t[V_t(\lambda^t)] = -D_t(\lambda^t),$$

and have argued that 15 is a reasonable hypothetical value for $D_t(\lambda^t)$. Thus, an increase in interest rates, if recognized immediately, generates a large decline in the value of outstanding liabilities, thereby tending to make pension plans *overfunded.*

Next, consider the effect of interest rates on fund assets. Assets can be decomposed into three categories: bonds, physical capital, and stock (leveraged physical capital). It is straightforward to calculate the effect of interest rates on the value of bonds. Suppose that, in period t, the pension fund contains bonds which provide a claim on the real income stream

$$B^t = (B^t_{t+1}, \ldots, B^t_{t+R}) \quad .$$

($B^t_{t+\tau}$ represents the income from bonds in period $t+\tau$ which the firm owns as of period t). Then, as before, for our elasticity measure,

$$\epsilon_r(B^t) = -D_t(B^t) \quad .$$

Again, we have no direct evidence of the average maturity of bonds held in pension plans. While we have noted the recent trends to "dedication" and "immunization" (section 3.1), we suspect that most plans hold bonds with short maturities relative to their liabilities. For purposes of hypothetical calculations, we will assume that the duration of bonds held in pension plans is 5 years. Thus, an increase in interest rates generates a significant decline in the value of bonds, thereby tending to make plans *underfunded.*

The case of physical assets is somewhat more complicated. Specifically, the effect of interest rates on physical asset valuation depends critically upon whether a change in interest rates represents a change in the return on all existing units, or a change in the return on marginal units only. We consider these cases separately.

Case 1: Change in return on all existing units.

In this case, the higher discount is matched by higher returns, so

$$\epsilon_r\,[V(P^t)] = 0 \quad .$$

(P^t represents the stream of returns associated with physical assets held by pension plans in period t.)

Case 2: Change in return on marginal assets only.

In this case, a physical asset is indistinguishable from a bond, so

$$\epsilon_r\,[V(P^t)] = -D_t(P^t) \quad .$$

Since real physical assets often include items such as real estate, for which durations are quite long, we choose as our hypothetical value $D_t(P^t) = 10$. Thus, in case 2, an increase in interest rates generates a large decline in the value of real physical assets, again tending to make plans *underfunded.*

Stocks can be thought of as leveraged physical assets, that is, as a combination of bonds and physical assets. To calculate the effects of interest rates on equity values, we simply combine the preceding formulas appropriately.

Let Y^t be the stream of income associated with the physical assets of firms in which our hypothetical pension plan holds common stocks. Let Z^t be the stream of outstanding liabilities arising from debt contracts of these same firms. Let E^t denote the stream of equity income:

$$E^t_{t+\tau} = (1 - C)(Y^t_{t+\tau} - Z^t_{t+\tau}) \quad .$$

(Here, C represents the corporate income tax rate.) Let α denote the debt-equity ratio of these firms:

$$\alpha = \frac{V_t(Z^t)}{(1 - C)\,[V_t(Y^t) - V_t(Z^t)]} \quad .$$

The effect of interest rates on equity values depends upon whether it involves case 1 or case 2, as defined above.

Case 1: $\epsilon_r[V_t(E^t)] = \alpha D_t(Z^t) \quad .$

Case 2: $\epsilon_r[V_t(E^t)] = \alpha D_t(Z^t) - (1 + \alpha)D_t(Y^t) \quad .$

In case 1, an increase in interest rates tends to improve the asset positions of pension plans holding stocks. In case 2, the effect is ambiguous. For our hypothetical calculations, we will take $\alpha = 1/2$, $D_t(Z^t) = 5$, and $D_t(Y^t) = 10$.

Now we assemble the various formulas given above. In year t, unfunded liabilities, U_t, are given by

$$U_t = V_t(\lambda^t) - V_t(B^t) - V_t(P^t) - V_t(E^t) \quad .$$

Thus, the change in unfunded liabilities (as a proportion of total liabilities) resulting from a change in the real interest rate is given by

$$\frac{1 + r}{V_t(\lambda^t)}\frac{dU_t}{dr} =$$

$$\epsilon_r[V_t(\lambda^t)] - \frac{V_t(B^t)}{V_t(\lambda^t)}\epsilon_r[V_t(B^t)] - \frac{V_t(P^t)}{V_t(\lambda^t)}\epsilon_r[V_t(P^t)] - \frac{V_t(E^t)}{V_t(\lambda^t)}\epsilon_r[V_t(E^t)] .$$

For purposes of calculations, we will assume that pension fund assets are evenly distributed between bonds, real assets, and stocks. Using the formulas and hypothetical parameter values listed above, we calculate two predicted responses of unfunded liablities to changes in the real interest rate, corresponding to the assumptions of case 1 and case 2:

Case 1: $$\frac{1 + r}{V_t(\lambda^t)}\frac{dU_t}{dr} = -14\frac{1}{6} .$$

Case 2: $$\frac{1 + r}{V_t(\lambda^t)}\frac{dU_t}{dr} = -5\frac{5}{6} .$$

In both cases, the response of net unfunded liabilities to a 1 percentage point change in the interest rate is large.

Now suppose that recognition and response effects were instantaneous—capitalization of the change is immediate, firms quickly switch to new interest rates for accounting purposes, and ERISA requires firms to fully fund plans at all times. Then the instantaneous response of net contributions to pension plans would be enormous. In the more conservative case, following a rise in real interest rates of 1 percentage point, contributions would fall by 25 percent of total private saving. Even if adjustments in personal portfolios offset 80 percent of this, private saving would still fall by 5 percent.

Of course, the response will not be instantaneous. While the evidence in section 3.1 suggests that interest rates employed for pension plan accounting do respond to market rates, they do so slowly. By accounting convention, the historical costs of bonds, rather than their current market values, are used to compute pension net unfunded liabilities, so relevant bond values do not immediately reflect changes in market conditions. Finally, ERISA permits firms to cover unfunded liabilities over relatively long periods. Thus, we would expect actual unfunded liabilities to be dissipated over a relatively long time horizon. Nevertheless, the magnitude of funding imbalances builds in significant downward pressure on the rate of contributions in the short run.

Rather than attempt to flesh out an explicit model of the adjustment process, we turn directly to empirical evidence. In the following section, we estimate both the short-run and long- run effects of real interest rate changes on the accumulation of pension fund assets.

3.3 Empirical Evidence

In the preceding sections, we have argued that institutional rules governing pension funds may significantly depress the response of private saving to changes in real interest rates, but no direct evidence has been offered to confirm or refute this hypothesis. In this section, we estimate a simple model of fund asset accumulation using aggregate time-series data. Our estimates corroborate the existence and magnitude of the effects described in section 3.2. However, we must stress that we provide no evidence concerning the extent of offsetting adjustments in personal portfolios. Several other papers have investigated related issues concerning the permeability of the corporate pension veil (see, e.g., Bulow, Morck, and Summers 1987, Feldstein and Morck 1983, and Feldstein and Seligman 1981); in this matter, we use existing estimates as a guide.

3.3.1 Estimation Technique

The object here is to estimate the effect of changes in real interest rates on gross contributions to pension funds and to use these estimates to compute the net effect on fund asset accumulation. To avoid problems with scaling, we will attempt to explain variations in the ratio of current contributions to current benefits. According to our model, in steady state this ratio is given by

$$\left(\frac{C_t}{B_t}\right)^* = \left[\frac{V_t(L^t)}{\lambda_t^t}\right]^* = g(X), \tag{3}$$

where $g(\cdot)$ is some function, X is a vector of exogenous variables, and asterisks (*) denote steady-state values. The vector X will include the interest rate, wage growth, and employment growth rates (this information determines the value of the function g) and information concerning the shape of new liability profiles. In steady state, the values of these variables remain unchanged, so we may omit a time subscript.

Since we do not observe the economy in steady state, it is impossible to estimate equation (3) directly. One must explicitly describe the process of adjustment before implementing the model with aggregate time-series data.

As stated in section 3.2.2, the adjustment to a new steady state is not instantaneous. Numerous factors induce lagged responses, including:

(1) the adjustment of expectations to a change in the current value of some variable (real interest rates or the rate of wage growth);

(2) the adjustment of assumed parameters used in pension fund accounting to changes in actual expectations concerning the corresponding market parameters;

(3) the revaluation of existing assets (such as bonds) under pension fund accounting conventions; and

(4) the adjustment of contributions to cover unfunded liabilities under ERISA regulations.

Undoubtedly, there are other sources of lags as well. Rather than model each separately to allow estimation of a structural model, we adopt a reduced form specification intended to represent the aggregate effects of these lags. Specifically,

$$\frac{C_t}{B_t} = g(X_t) + \sum_{\tau=0}^{\infty} \Delta X_{t-\tau}\mu_\tau \tag{4}$$

Note that if the vector X_t has remained at its current rate since the beginning of time, C_t/B_t will assume the steady-state value associated with X_t.

Estimation of this relationship requires several simplifications. First, we linearize $g(\cdot)$:

$$g(X_t) = X_t\alpha \quad .$$

Second, we restrict the lag structure as follows. We allow μ_0 and μ_1 to be estimated freely and require that the effects of all right-hand-side variables thereafter decline at the common geometric rate, μ (a scalar). That is, for t $\geq$ 2,

$$\mu_t = \mu_{t-1}\mu \quad .$$

Formally, it would be easy to allow additional flexibility by estimating $(\mu_0, \ldots, \mu_k)$ without restriction and requiring geometric decline thereafter. However, this consumes valuable degrees of freedom. Given the length of our sample period, a relatively restrictive specification was essential.

When these restrictions are imposed, it is possible to simplify our basic functional specification, equation (4), as follows:

$$\frac{C_t}{B_t} = X_t\alpha(1 - \mu) + \Delta X_t(\mu_0 + \alpha\mu) + \Delta X_{t-1}(\mu_1 - \mu\mu_0) + \mu\frac{C_{t-1}}{B_{t-1}} \quad . \tag{5}$$

As a practical matter, we will recover estimates of μ and the parameter vectors α, μ_0, and μ_1 by estimating the following relationship:

$$\frac{C_t}{B_t} = X_t\beta_0 + \Delta X_t\beta_1 + \Delta X_{t-1}\beta_2 + \mu\frac{C_{t-1}}{B_{t-1}} + \epsilon_t \quad . \tag{6}$$

Note that equation (6) is linear in variables and parameters. Furthermore, equation (5) implies no restrictions on the coefficients in equation

(6). Thus, we can estimate equation (6) using standard techniques (see subsection 3.3.3). This will yield an estimate of μ directly. Other primitive parameters can be recovered as follows:

$$\alpha = \beta_0/(1 - \mu) \quad , \tag{7}$$

$$\mu_0 = \beta_1 - \alpha\mu \quad , \tag{8}$$

$$\mu_1 = \mu\mu_0 + \beta_2 \quad . \tag{9}$$

Under the assumption that ϵ_t is independently and identically distributed and independent of contemporaneous right-hand-side variables (interest rates, wage rates, etc.), equation (5) may be estimated with ordinary least squares (OLS). While the second assumption does not trouble us, the first is a serious concern. Specifically, if ϵ_t is autocorrelated, C_{t-1}/B_{t-1} will be correlated with ϵ_t, and OLS estimates will be inconsistent. Consequently, we also estimate equation (6) with two-stage least squares (2SLS), instrumenting for C_{t-1}/B_{t-1} using lagged values of the other independent variables. This produces consistent estimates. However, consistency is highly sensitive to the functional specification. If our restrictions on the functional form are invalid (if, for example, the μ_t's decline geometrically after *two* lags), our instruments will be invalid. Unfortunately, there are, of necessity, no alternative candidates.

3.3.2 Data

Now the procedure described above will be implemented with aggregate U.S. time-series data. Our variables and their sources are as follows:

G_t = Annual gross contributions by employers to private pension and profit-sharing plans, as reported in the National Income and Product Accounts (NIPA) data (see *Survey of Current Business*, July issue of each year). This figure is derived from the reports of contributions on employers' tax returns. Unfortunately, a breakdown between defined benefit and other plans is unavailable. The series begins in 1951.

R_t = The dollar value of reversions to plan sponsors. Data on reversions have been collected by the Pension Benefit Guarantee Corporation since 1980, before which they were not an important phenomenon.

C_t = Annual contributions by employers to private pension and profit-sharing plans, net of reversions ($C_t = G_t - R_t$).

B_t = Benefits paid by private pension and welfare plans, as given in the NIPA data. This series is constructed primarily from data on pension income reported on individual income tax returns and is available beginning in 1952.

i_t = The nominal rate of interest, defined as the average annual rate paid on Aaa long-term corporate bonds.

v_t = The annual rate of change of wages and salaries for the average full-time equivalent employee, as measured by the NIPA.

s_t = The annual total return (dividends plus capital gains) for the Standard and Poor's 500 stock index.

p_t = The annual rate of inflation, as measured by the year-to-year percentage change in the GNP deflator.

Each of these rates (i_t, v_t, s_t, p_t) is measured in *percentage points*, rather than fractions of unity. We also define the following real rates of interest, wage-salary growth, and equity return:

$$r_t = i_t - p_t \quad ,$$

$$w_t = v_t - p_t \quad ,$$

$$e_t = s_t - p_t \quad .$$

We do not mean these to represent *expected* real rates in any period. Rather, they are actual *ex post facto* rates. Recall that our specification is designed to capture various lagged effects, including the adjustment of expectations to changes in *ex post facto* values.

Note that most of our data predate ERISA. While firms undoubtedly had greater flexibility in funding pension plans prior to federal regulation, we suspect that most firms gravitated (however slowly) toward full funding. Presumably, the existence of ERISA will make pension fund contributions more responsive to interest rates than these data suggest.

3.3.3 Estimates and Interpretation

Estimates of equation (6) are presented in this section. We took the vector of independent variables, X_t, to include a constant term, the real interest rate, the real rate of wage-salary growth, the residual real rate of equity return, and the rate of inflation (for ΔX_t we omitted the constant term, for obvious reasons). We constructed the residual rate of equity return, er_t, as follows: we regressed the current real rate of equity return on r_t, w_t, and p_t, and set er_t equal to the fitted residuals. Our justification for this procedure is that we are interested in all direct and indirect effects of changes in r_t on rates of contributions. If an unexpected rise in r_t causes a change in stock values, thereby altering the value of pension fund assets, which in turn precipitates adjustments in contributions, this is a legitimate effect.

We estimated two versions of equation (6). In the first, we imposed no constraints on coefficients. In the second, we constrained the coefficient of $r_t(\beta_0^r)$ to equal the negative of the coefficient of $w_t(\beta_0^w)$. In the long run, it is clearly the *difference* between r_t and w_t which is relevant for determining pension fund balance. Each version of equation (6) was estimated using both OLS and 2SLS techniques (see subsection 3.3.1) on aggregate annual time-series data, from 1952 to 1982 (see subsection 3.3.2). The results are presented in table 3.7.

Several aspects of table 3.7 deserve immediate comment. Note that the signs of the coefficients on r_t, w_t, er_t, and p_t determine the direction of the long-run effects of these variables on contributions (see equation [7]). Thus, we see that the long-run interest and wage growth effects have the anticipated signs. In fact, for both instrumented and uninstrumented versions, the absolute value of the coefficient on r_t is nearly the same as the coefficient of w_t, as predicted, so that imposing this constraint changes the estimates by negligible amounts. Note that the inflation rate increases long-run contributions (although the effect is not statistically significant in three out of four equations). Strictly speaking, this is inconsistent with our model—the requirement of full funding determines C_t/B_t independent of inflation. However, in practice, firms may have the ability to somewhat overfund or underfund plans in the long run. With higher inflation rates, pension funds form a more desirable tax dodge; hence, contributions may increase with inflation. Finally, observe that long-run contributions rise with er_t, although the coefficient is only marginally significant. In steady state, changes in er_t presumably reflect changes in the risk premium associated with equity. Thus, the corresponding coefficient implies that contributions increase as the risk premium associated with equity rises. Perhaps this reflects caution on the part of firms when facing greater variability on earnings from assets.

While one might be tempted to interpret the other coefficients in table 3.7 directly, this is potentially misleading. Only the primitive coefficients can be easily interpreted, and thus they must be recovered by unscrambling our estimates using equations (7), (8), and (9). Since we are primarily concerned with assessing the effects of interest rates on contributions, we recover only those primitive parameters bearing directly on this issue (μ, α^r, μ_0^r, and μ_1^r). These estimates, along with asymptotic standard errors, are presented in table 3.8.

To interpret these coefficients, recall our basic specification (equation [3]). The coefficient α^r measures the long-run impact of the real interest rate on pension plan contributions (with wages fixed, interest rates do not affect benefits, the denominator). In particular, the OLS estimates indicate that a 1 percentage point increase in the real interest rate will depress C_t/B_t in the long run by more than 0.4 (40 percent of benefits). If the long-run value of C_t/B_t is approximately 2, this implies a long-run interest elasticity of contributions in the neighborhood of -20. (Again, in this section, the elasticity is the percentage change in contributions for a 1 percentage point change in the interest rate.) 2SLS estimates imply that the magnitude of this effect is 50 percent *larger*.

Table 3.7 **Estimated Equations**

Variable	OLS Unconstrained	OLS Constrained	2SLS Unconstrained	2SLS Constrained
constant	0.398	0.460	1.45	1.55
	(0.208)	(0.168)	(0.76)	(0.66)
r_t	−0.093	−0.097	−0.416	−0.425
	(0.035)	(0.033)	(0.076)	(0.066)
Δr_t	−0.013	−0.004	0.153	0.168
	(0.043)	(0.038)	(0.128)	(0.113)
Δr_{t-1}	−0.024	−0.021	0.240	0.245
	(0.048)	(0.047)	(0.139)	(0.134)
w_t	0.118	0.097	0.460	0.425
	(0.052)	(0.033)	(0.142)	(0.066)
Δw_t	−0.056	−0.046	−0.365	−0.347
	(0.040)	(0.034)	(0.102)	(0.079)
Δw_{t-1}	−0.038	−0.033	−0.230	−0.222
	(0.028)	(0.026)	(0.076)	(0.069)
er_t	0.0076	0.0072	0.029	0.029
	(0.0040)	(0.0039)	(0.012)	(0.012)
Δer_t	−0.0065	−0.0064	−0.021	−0.021
	(0.0029)	(0.0029)	(0.009)	(0.009)
Δer_{t-1}	−0.0029	−0.0027	−0.011	−0.011
	(0.0019)	(0.0010)	(0.006)	(0.006)
p_t	0.027	0.020	0.062	0.051
	(0.016)	(0.010)	(0.060)	(0.046)
Δp_t	−0.075	−0.070	−0.210	−0.201
	(0.036)	(0.033)	(0.108)	(0.100)
Δp_{t-1}	−0.053	−0.054	0.003	0.0021
	(0.053)	(0.041)	(0.135)	(0.133)
C_{t-1}/B_{t-1}	0.775	0.777	0.343	0.349
	(0.057)	(0.056)	(0.195)	(0.189)
Durbin-Watson	2.66	2.68	1.54	1.56
Standard Error of Regression	0.088	0.087	0.280	0.273

NOTE: OLS = ordinary least squares; 2SLS = two-stage least squares. Standard errors given in parentheses.

The estimates of μ_0^r and μ_1^r indicate a relatively smooth, monotonic adjustment of C_t/B_t to its steady-state value. In the first year following a 1 percentage point rise in the real rate of interest, C_t/B_t changes by $\alpha^r + \mu_0^r$. For the OLS estimates, $\alpha^r + \mu_0^r \approx -0.1$, which implies a short- run impact elasticity in the neighborhood of -5 (one-quarter of the adjustment in C_t/B_t occurs in the first year). For the 2SLS estimates, the impact elasticity is much higher (approximately -13), and a larger proportion of the adjustment (more than one-third) occurs in the first year. Both OLS and 2SLS estimates imply that just under half of the

Table 3.8 **Primitive Parameters**

Parameter	OLS Unconstrained	OLS Constrained	2SLS Unconstrained	2SLS Constrained
μ	0.775	0.777	0.343	0.349
	(0.057)	(0.056)	(0.195)	(0.189)
α^r	−0.413	−0.435	−0.633	−0.653
	(0.089)	(0.067)	(0.146)	(0.129)
μ_0^ζ	0.307	0.334	0.370	0.396
	(0.085)	(0.057)	(0.370)	(0.181)
μ_1^ζ	0.214	0.239	0.367	0.383
	(0.048)	(0.047)	(0.139)	(0.134)

NOTE: OLS = ordinary least squares; 2SLS = two-stage least squares. Standard errors given in parentheses.

adjustment is complete by the second year. Thereafter, 2SLS estimates imply much more rapid adjustment to the steady state (compare the values of μ). It is interesting to note that, for the OLS estimates, $\mu_1^\zeta \approx \mu\mu_0^\zeta$, so that the additional flexibility offered through inclusion of the lagged parameter makes very little difference.

To assess more fully the implications of our estimates, we calculate implied steady-state values of (C_t/B_t) and (A_t/B_t) under different interest rate assumptions. As mentioned earlier, the implied steady-state value of (C_t/B_t) is given by substituting values of variables and parameters into equation (4), where $\Delta X_{t-\tau}$ is set equal to zero for all τ. Obtaining the implied steady-state value of A_t/B_t is only slightly more difficult. Along any path, the value of pension assets evolves as follows:

$$A_{t+1} = (1 + \rho_t)A_t + C_t - B_t \quad . \tag{10}$$

Here, ρ represents the rate of return on the pension portfolio. This may differ from r_t because of the risk characteristics of this portfolio. Equation (10) can be rewritten as

$$\frac{A_{t+1}}{A_t} = (1 + \rho_t) + \left(\frac{C_t}{A_t}\right) - \left(\frac{B_t}{A_t}\right) \quad .$$

In steady state, $A_{t+1}/A_t = 1 + g$, the growth rate of pension benefits. Thus,

$$(1 + g) = (1 + \rho) + \left(\frac{C_t}{B_t}\right)^* \left(\frac{B_t}{A_t}\right)^* - \left(\frac{B_t}{A_t}\right)^* .$$

Solving for $(A_t/B_t)^*$,

$$\left(\frac{A_t}{B_t}\right)^* = \frac{1 - (C_t/B_t)^*}{\rho - g} \quad . \tag{11}$$

Given values of r, w, er, g, and the risk premium associated with pension funds ($\rho - r$), we can calculate $(C_t/B_t)^*$ and $(A_t/B_t)^*$ through equations (4) and (11).

The calculations for these steady-state contribution and asset ratios are presented in table 3.9. We set the variables appearing in our regression analysis equal to their recent (20-year) historical averages. Columns designated "initial" refer to an assumed real interest rate of 0.025. Columns labeled "final" refer to an assumed real interest rate of 0.015. We take $\rho - r = 0.03$, and $g = 0.10$. This assumed rate of real pension benefit growth may seem quite high, but it accords with historical experience, presumably because of the immaturity of most pension programs. We chose to make our calculations using the value of g which prevailed for the sample period, rather than a more "realistic" steady-state value, because our estimates may be unreliable in a regime of substantially lower pension benefit growth.

Recall from our theoretical discussion that the (absolute) long-run interest elasticity of contributions should equal the duration of newly accrued pension liabilities while the (absolute) long-run interest elasticity of assets should equal the duration of outstanding liabilities. Of course, one must adjust for the fact that approximately one-third of pension plans are not defined benefit. Nevertheless, all estimates appear to be roughly consistent with the magnitudes proposed in section 3.2. Only one anomaly appears: for the 2SLS estimates, the implied duration of outstanding liabilities slightly exceeds the duration of newly accrued liabilities. We suspect that our estimates of $(A_t/B_t)^*$ are not entirely reliable due to the maturation of the pension system during our sample period. We hope to improve these calculations in subsequent study.

3.4 Conclusion

In this paper, we have developed a simple analytical model which suggests that the long-run percentage responsiveness of contributions

Table 3.9 Long-Run Impacts of Real Interest Rate Changes

	$(C/B)^*$			$(A/B)^*$		
Version	Initial	Final	% Change	Initial	Final	% Change
Uninstrumented, Unconstrained	2.070	2.475	19.6	24.18	27.04	11.8
Uninstrumented, Constrained	2.026	2.460	21.4	23.19	26.76	15.4
Instrumented, Unconstrained	2.008	2.640	31.5	22.78	30.06	32.0
Instrumented, Constrained	1.982	2.635	32.9	22.19	29.97	34.8

to a 1 percentage point increase in the interest rate should equal the duration of newly accrued pension liabilities, and the responsiveness of pension assets should equal the duration of existing liabilities. The OLS and 2SLS aggregate time-series estimates of section 3.3 are remarkably consistent with this model. This analysis suggests that the operation of pension funds may significantly affect the way our economy responds to incentives for capital formation.

The importance of this target-saving/negative elasticity of contributions theory has been borne out by recent economic experience. Real interest rates have been at record levels for the past three years, and the effect this has had on pension funding has been considerable. The earnings of pension fund assets have been much greater than actuarial assumptions with the result being that a majority of pension funds are fully funded (even at their still-below-market assumed interest rates), and net contributions are down over $30 billion since 1982. Net contributions are likely to remain below the 1982 level because of the considerable lags in the pension actuarial system. Such recent and increasingly important phenomena as pension reversions, dedications, and immunizations also reflect the gap between market interest rates and the previously assumed rates, and they reinforce the downward pressure on loanable fund saving from this source. Thus, adjustments of pension fund contributions may continue to depress personal saving for years to come.

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Comment Eugene Steuerle

In their paper, Bernheim and Shoven make a valuable contribution to recent attempts to explain both changes in personal saving rates and changes in the net flow of funds into pension plans. To the extent that pension plans are designed to meet certain target saving goals, pension funding (contributions less payments) will have a negative elasticity (or, more exactly, responsiveness) to changes in the real interest rate.

The arguments are intuitively appealing and, from my discussions with other experts on pensions, provide a rational explanation of much current activity. The tax laws limit overfunding with respect to pension plans. While higher real interest rates might eventually lead to increased benefit levels, over the short run they are likely to lead to lower levels of funding for a promised or targeted level of benefits. Regardless of the underlying reasons, both actuaries and managers of firms do fund pension plans to reach some target level of benefits.

While Bernheim and Shoven have enhanced our understanding of one important influence on pension funding, in the ideal, one would want to test the relative impact of all other influences on pension funding. Unfortunately, Bernheim and Shoven only have 31 observations of data (from an annual time series from 1952 to 1982) and have few degrees of freedom left in a model with 13 independent variables plus a constant term. With so few observations, it is not clear how alternative theories could be tested.

I will list some additional factors that I believe had a significant impact on pension funding over the period of time examined by Bernheim and Shoven.

First, the Pension Reform Act of 1974 forced funding of many plans that were underfunded prior to that time. Underfunding is advantageous to stockholders because some *expected* costs are shifted to workers

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and government as long as there is some probability of bankruptcy in the future. The passage of the 1974 Act therefore should have increased pension funding for several years, but in a declining fashion as more and more plans became fully funded.

Second, the IRS imposes limits on funding that operate differently with different rates of inflation. The tax laws not only set a maximum level of benefits that can be provided under a qualified plan, but they also disallow contributions necessary to fund future expected increases in that maximum amount due to *future* inflation. As expected inflation increases, it becomes more likely that more workers (especially younger workers) will be entitled to benefits in excess of the maximum amount allowed to be funded by the IRS. In addition, higher rates of inflation generally lower the real benefits that will be paid to workers who leave a firm before retirement. Thus, inflation might be expected to have a negative impact on funding in pension plans, although Bernheim and Shoven find the opposite (usually statistically insignificant) result.

Third, changes in income and Social Security tax rates should have a major impact on pension funding. Higher tax rates enhance the benefits of the tax preference granted to saving through pension plans. These tax rates have changed substantially over the period of time analyzed by Bernheim and Shoven.

Fourth, the changing demographic nature of the population should affect levels of funding. In general, the current tax treatment of fringe benefits tends to discriminate against secondary workers (Kosters and Steuerle 1981). In the case of pensions, the greater turnover rate for secondary workers should decrease the amount of expected benefits that would be paid out under typical defined benefit plans designed for long-term workers.

Fifth, some changes in pension funding could reflect cyclical, as well as long-term, adjustments. I have shown elsewhere how after-corporate-tax payments to owners of corporate capital tend toward constancy over the economic cycle (Steuerle 1985). A pension fund offers managers a ready device by which to steady the reported earnings stream over time. Thus, it is possible that some adjustments in payments to pension plans merely reflect cyclical, rather than long-term, responses to changes in interest rates.

Sixth, there is a substantial debate over the extent to which the increased availability of IRAs and other defined contribution options reduces the demand of workers for defined benefit plans. Certainly some offset has taken place over the same period of time that real interest rates have risen.

Finally, as noted above, increases in the inflation rate have decreased the real liabilities of defined benefit pension plans. Any model may have difficulty separating out this effect if the lag with which actuaries respond to these changes is unknown. I have argued that some of the reductions in funding in the 1980s should be attributed to this decline in real liabilities, although I have not tested this conclusion. A survey of changes in actuarial assumptions in major pension plans could help resolve the question of how long it takes for changes in inflation and real interest rates to affect funding within pension plans.

In summary, Bernheim and Shoven have enhanced our understanding of recent changes in pension funding. Changes in real interest rates are likely to have a significant impact on pension funding under any targeted benefit approach. While their logic is clear, the number of data observations is inadequate to test the relative importance of this one factor relative to other factors known to have been operating at the same time.

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