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PENSION FUNDING AND SAVING

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ABSTRACT

This paper suggests that the nature of the funding of defined benefit pension plans may be an important reason why personal saving has not responded positively to the high real interest rates and tax incentives to encourage saving and investment of the last few years. From a firm's standpoint, funding the promised pension is a target, and higher rates of return permit reaching that target with lower contributions. According to the Flow of Funds Accounts of the Federal Reserve System between 1982 and 1984, net pension contributions declined from 6.02 percent of disposable personal income to 4.02 percent.

The paper presents empirical information regarding pension contributions, unfunded liabilities, interest rates, and recent developments in pension funding. It specifies the target saving model of pension funding and derives the theoretical elasticity of pension contributions to changes in interest rates. It then investigates this elasticity with aggregate time series econometrics. In general, the estimated elasticities are consistent with the theory and indicate that one percentage point rise in real interest rates would, in the long run, reduce pension contributions between 20 and 30 percent. Such a large negative elasticity for such an important source of loanable funds in the economy suggests that the pensions funding mechanism should be taken into account in designing policies to increase the economy's saving and investment.

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I. Introduction

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 Keough 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 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 1970's 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 dissagregated 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 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 the 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 is possibly large enough to be responsible for the disappointing level of aggregate personal saving.

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 -- and 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 over-funded plan, the law may force a reduction or an elimination of contributions. Just the 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. We have not investigated whether the private sector offsets this reduction in the contributions to pension plans, but previous research suggests that this offset will only be partial (Feldstein and Seligman (1981), Feldstein and Morck (1983), Bulow, Morck, and Summers (1986)). It should be emphasized that the negative elasticity of contributions to a defined benefit pension plan is not the result of inter-temporal optimization on the part of either the firm or the workers, but is a purely mechanical response inherent in the funding rules for these types of plans.

In the next section of this paper, we present some empirical information regarding pension contributions, unfunded liabilities, assumed interest rates, and recent developments in pension funding. Then in the third section of the paper, we present our target saving model of pension funding and derive the elasticity of contributions to changes in interest rates. The fourth section 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 close the paper by summarizing our findings in the conclusion.

II. Institutional Considerations

As Table 1 shows, most pension plans (72 percent of them) are defined contribution. However, the defined contribution plans are typically small and often supplement a defined benefit plan (a notable exception being TIAA-CREF, which is the largest pension plan in the United States). Thus, 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 the $377 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 compared to household corporate equity holdings of $741 billion.

Table 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 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 under a one percent yearly rate. The changes in the relative popularity of defined benefit vs. defined contribution plans is almost certainly due to the funding, vesting, and insurance requirements of ERISA for defined benefit plans.

TABLE 1

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

	Defined Benefit	Defined Cont.	Total
Plans (#)	139,340 (28.1%)	356,505 (71.9%)	495,845
Participants	36.1 mil (68.2%)	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: Estimates of Participant and Financial Characteristics of Private Pensions Plans, 1983, DOL

TABLE 2

Number and Growth of Pension Plans by Type

Year	Defined Benefit Qualified	Defined Benefit Terminated	Defined Benifit Qualified Minus Terminated	Defined Benefit Plans	
				Total Number	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	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		

DOL Universe 1977-80 with estimates for other years based on IRS Data.
Data provided by the Employee Benefit Research Institute.

There are two sources of data regarding aggregate private pension contributions and benefits, the Flow of Funds data of the Federal Reserve and the National Income and Product Account (NIA) information. As with total saving figures, the two sources do not agree particularly well on the numbers. The time series on net contributions (contributions less benefits paid out) from the Flow of Funds information is shown in Table 3 for 1948 through 1984. 1984 numbers show a fairly drastic decline. The 1984 figure for private pensions alone was more than $30 billion less than for 1982. The growth rate in net contributions 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 contributions from a trend line is comparable to the total inflow of money into IRA and Keough accounts. Thus, the data makes it appear that the story may be large relative to the saving incentives mentioned in the introduction. The relative importance of pension contributions to personal saving can be judged by comparing columns (4) and (5) of Table 3.

The NIA data, which we use in the empirical work of the next section, is shown in the first two columns of Table 4 for private pensious. The NIA provides separate information on contributions and benefits paid and we generally consider it to be more reliable than the Flow of Fund numbers. The NIA contribution figures are based on business tax return information, while their numbers for benefits are based on individual tax returns netted out for government pensions. The NIA information is not yet available for 1984, so our estimations of the section IV will not use the dramatic developments of last year. The third column of Table 4 contains information on reversions. Reversions have received a lot of attention recently, partly due to the fact that a few large publicly held companies have terminated their 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

TABLE 3

Net Contributions to Pension Funds ($ Billion)

(Flow of Funds, Federal Reserve)

Year	Private (1)	Insured (2)	State/Local (3)	TOTAL (4)	NIA 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	--

TABLE 4

NIA Data on Private Pension Contributions, Benefits and Reversions

Year	Private Pension Contributions[1]	Private Pension Benefits Paid[2]	Reversions[3]
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

SOURCES: 1 and 2, NIPA, "Other Labor Income by Industry and Type," (in bil.$)
3, Pension Benefits Guarantee Corporation (in bil. $)

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 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 below.

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: "1984 Survey of Actuarial Assumptions and Funding," The Wyatt Company.

However, this growth in the assumed interest rate has been matched by increases in the assumed salary growth for the seventy 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 slightly in the past eight years. Since 1976, the average spread has decreased from 2.3 percent to 1.5 percent.

The adjustment towards market interest rates may be occuring 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 5 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 5 were requested by the Financial Accounting Standards Board Statement No. 36 and did not permit the use of salary growth projections. Many companies do make these projections in calculating 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 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.

III. Theoretical Considerations

In the previous section, 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. The current section exhibits a simple model of defined-benefit pension plans, for which we compute

TABLE 5

Distribution of Vested Funded Ratios
For the Fortune 500 Industrials for 1983

	With Assumed Interest Rates		With 10% Interest Rate	
	Percent of Companies			
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: "Pension-Related Financial Data in the Fortune 500 Industrials," 1984 edition, Hewitt Associates, Lincolnshire, Illinois.

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 IV 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:

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

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

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

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

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

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

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

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 is approximately the percentage change in value per <u>percentage point</u> 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 one dollar 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 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 one percentage point move in the interest rate from, say, four to five percent rather than a one percent change from 4.00 to 4.04 percent.

In this paper, we will be concerned with changes in the real interest rate. In order to avoid unnecessary notation, we simply denote every stream in real dollars, and discount by the real rate. Subsections A and B consider long run, and short run effects, respectively.

A. Long Run Effects of Changes in the Real Interest Rate

ERISA regulations permit temporary underfunding and overfunding of pension plans, but require that the firm fully fund its liabilities 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:

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

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 <u>exactly</u>. Thus, to maintain full funding, current contributions, C_t, must equal the value of new accrued liabilities:

$$(2) \qquad C_t = V_t(L^t)$$

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 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 savings, defined as the response of savings to a change in the interest rate given fixed values of other variables (such as wage rates and employment), often appears as a critical parameter in policy analyses. Consequently, many authors have attempted to measure personal savings 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

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

where, again, this elasticity is the percentage change in the value of assets for a one 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

$$\varepsilon_r(C_t) = - D_t(L^t)$$

Here, we clearly see the "target saving" aspect of defined benefit pension programs: if all savings takes place to fund an expenditure in the following period ($D_t(L^t) = 1$), then the elasticity of savings 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 hypothetic 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 mangitudes, this translates into roughly $25 billion.

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

$$N_t = C_t + rA_t - B_t$$

(where benefits paid, $B_t \equiv \lambda_t^t$). 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

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

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 savings.

It is useful to summarize the changes in net pension saving relative to total personal savings, 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

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

$$= .5\ \varepsilon_r(C_t) + .1\ \varepsilon_r(rA_t)$$

Using our previous values for stream durations,

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

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 savings 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.

B. 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? We find it 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? We tackle these questions 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

$$\varepsilon_r(V_t(\lambda^t)) = - D_t(\lambda^t),$$

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 plans overfunded.

Next, consider the effect of interest rates on fund assets. Assets can be decomposed into three categories: bonds, physical capital, and stock (levered 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

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

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

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

Again, we have no direct evidence on the average maturity of bonds held in pension plans. While we have noted the recent trends to "dedication" and "immunication" (section II), 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 <u>underfunded</u>.

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 existing units, or a change in the return on marginal units only. We consider these cases separately.

<u>Case 1</u>: Change in return on all existing units.

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

$$\varepsilon_r\ (V(P^t)) = 0$$

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

<u>Case 2</u>: Change in return on marginal assets only.

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

$$\varepsilon_r\ (V(P^t)) = -D_t(P^t)$$

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 a levered physical assets, i.e., 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:

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

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

$$\alpha = \frac{V_t(Z^t)}{(1-C)(V_t(Y^t) - V_t(Z^t))}$$

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

<u>Case 1</u>: $\varepsilon_r(V_t(E^t)) = \alpha D_t(Z^t)$

<u>Case 2</u>: $\varepsilon_r(V_t(E^t)) = \alpha D_t(Z^t) - (1+\alpha)D_t(Y^t)$

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 $\alpha = \frac{1}{2}$, $D_t(Z^t) = 5$, and $D_t(Y^t) = 10$.

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

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

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

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

$$- \frac{V_t(P^t)}{V_t(\lambda^t)} \varepsilon_r(V_t(P^t)) - \frac{V_t(E^t)}{V_t(\lambda^t)} \varepsilon_r(V_t(E^t))$$

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 liabilities to changes in the real interest rate, corresponding to the assumptions of case 1 and case 2.

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

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

In both cases, the response of net unfunded liabilities to a one 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 savings. Even if adjustments in personal portfolios offset 80 percent of this, private savings would still fall by five percent.

Of course, the response will not be instantaneous. While the evidence in section II 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 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 and long run effects of real interest rate changes on the accumulation of pension fund assets.

IV. Empirical Evidence

In the preceding sections, we have argued that institutional rules governing pension funds may significantly depress the response of private savings to changes in real interest rates, but have offered no direct evidence to confirm or refute this hypothesis. In this section, we estimate a simple model of fund accumulation using aggregate time series data. Our estimates corroborate the existence and magnitude of the effects described in section III. However, we must stress that we provide no evidence concerning the extent of offsetting adjustments in personal portfolios. Several other papers have investigated the permeability of the corporate pension veil; in this matter, we use existing estimates as a guide.

A. Estimation Technique

Our object 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

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

where g(.) is some function, X is a vector of exogenous variables, and stars (*) 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 (3) directly. One must explicitly describe the process of adjustment before implementing the model with aggregate time series data.

As we have remarked in section III.B, 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,

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

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(.):

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

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 (μ_0, ..., μ_k) without restriction, and requiring geometric decline thereafter. However, this consumes valuable degrees of freedom. Given the length of our sample period, we felt that a relatively restrictive specification was essential.

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

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

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:

$$\text{(6)} \qquad \frac{C_t}{B_t} = X_t\beta_0 + \Delta\ X_t\beta_1 + \Delta\ X_{t-1}\beta_2 + \mu\ \frac{C_{t-1}}{B_{t-1}} + \varepsilon_t$$

Note that (6) is linear in variables and parameters. Furthermore, (5) implies no restrictions on the coefficients in (6). Thus, we can estimate (6) using standard techniques (see below). This will yield an estimate of μ directly. Other primitive parameters can be recovered as follows:

$$\text{(7)} \qquad \alpha = \beta_0/(1 - \mu)$$

$$\text{(8)} \qquad \mu_0 = \beta_1 - \alpha\ \mu$$

$$\text{(9)} \qquad \mu_1 = \mu\ \mu_0 + \beta_2$$

Under the assumption that ε_t is i.i.d. and independent of contemporaneous right hand side variables (interest rates, wage rates, etc.), equation (5) may be estimated with ordinary least squares. While the second assumption does not trouble us, the first is a serious concern. Specifically, if the ε_t are autocorrelated, C_{t-1}/B_{t-1} will be correlated with ε_t, and OLS estimates will be inconsistent. Consequently, we also estimate (6) with two stage least squares, 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.

B. Data

We implement the procedure described above 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 the Survey of Current Business, July issue of each year). This figure is derived from reporting 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 (see above). 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:

$$r_t = i_t - p_t$$

$$w_t = v_t - p_t$$

$$e_t = s_t - p_t$$

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

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

C. Estimates and Interpretation

In this section, we present estimates of equation (6). 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 (see below), and the rate of inflation (for ΔX_t, we ommitted 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 <u>and</u> 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 <u>difference</u> 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 A) on aggregate annual time series data, from 1952 to 1982 (see subsection B). The results are presented in Table 6.

Several aspects of Table 6 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

TABLE 6

Estimated Equations

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

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 over 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 6 directly, this is potentially misleading. Only the primitive coefficients are easily interpretable, and thus 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 7.

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 one 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

TABLE 7

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^r	0.307	0.334	0.370	0.396
	(0.085)	(0.057)	(0.370)	(0.181)
μ_1^r	0.214	0.239	0.367	0.383
	(0.048)	(0.047)	(0.139)	(0.134)

approximately 2, this implies a long run interest elasticity of contributions in the neighborhood of -20.* 2 SLS estimates imply that the magnitude of this effect is 50 percent <u>larger</u>. See below for a more complete discussion.

The estimates of μ_0^r and μ_1^r indicate a relatively smooth, monotonic adjustment of C_r/B_t to its steady state value. In the first year following a one point rise in the real rate of interest, C_t/B_t changes by $\alpha^r + \mu_0^r$. For the OLS estimates, $\alpha^r + \mu_0^r \sim -0.1$, 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 adjustment is complete by the second year. Thereafter, 2SLS estimates imply much more rapid adjustment to the steady state (compare the values of the μ). It is interesting to note that, for the OLS estimates, $\mu_1^r \sim \mu\ \mu_0^r$, 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:

$$(10) \qquad A_{t+1} = (1 + p_t)A_t + C_t - B_t$$

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* Again, in this section, the elasticity is the percentage change in contributions for a one percentage point change in the interest rate.

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

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

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

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

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

$$(11) \qquad \left(\frac{A_t}{B_t}\right)^* = \frac{1 - (C_t/B_t)^*}{p - g}$$

Given values of r, w, er, g, and the risk premium associated with pension funds, $(p - r)$, 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 8. 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 interest rate of 0.015. We take $p - r = 0.03$, and $g = 0.10$. This assumed rate of real pension benefit growth may seem quite high, but accords with historical experience, presumably due to 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 by unreliable in a regime of substantially lower pension benefit growth.

TABLE 8

Long Run Impacts of Real Interest Rate Changes

Version	(C/B)*			(A/B)*		
	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

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 plans are not defined benefit. Nevertheless, all estimates appear to be roughly consistent with the magnitudes proposed in section III. Only one anomoly appears: for the 2 SLS 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, and hope to improve these calculations in further revisions.

V. Conclusion

We are reluctant to draw too many strong conclusions at this relatively preliminary stage in our research. However, the target saving/negative elasticity of contributions story for defined benefit pension plans seems to hang together well in both a theoretical and empirical investigation. 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 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 dollars 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 reinforce the downward pressure on loanable fund savings from this source.

We developed a simple analytical model which suggested that the long run percentage responsiveness of contributions to a one 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 our empirical section are remarkably consistent with this model.

Pension funds are an important institutional feature in U.S. capital markets. Their operation can, and we feel has, affected the way the economy responds to capital formation incentives. In the future, policies which take into account the operation of pensions should be investigated.

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