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THE FUNDING STATUS OF TEACHER PENSIONS: AN ECONOMETRIC APPROACH

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ABSTRACT

The financing of public employee pensions has become an issue of growing public concern. This paper examines the funding status of teacher pension plans for the fifty states and for selected localities for the decade, 1971-1980. A pension underfunding equation based upon actuarial principles is specified and estimated using a sample of pension plans for which actuarially sound measures of underfundings are available. The econometrically-estimated pension equation is then used to "predict" underfundings for each state and local pension plan for each year for which full pension plan data are available. The results reveal that the real dollar value of plan underfundings has risen by over 50% in the average state from 1971-1980. Strategies for funding these growing pension deficits are required.

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The Funding Status of Teachers' Pensions: An Econometric Approach

by

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The financing of public employee pensions has become an issue of growing public concern. While the number of actual defaults are few, numerous recent estimates by actuaries and economists suggest that there may be significant funding deficits in our public employee retirement systems.[1] Underfunding occurs because promised pensions to current and future system retirees are not backed by an adequate volume of accumulated assets and planned contributions. When an underfunding occurs, either employee pensions benefits must be reduced, or public services must be curtailed, or taxpayer and current employee contributions must be increased.

When the level of underfunding is small and the pension system is young (a low current retiree/membership ratio) such adjustments in benefits, services, or contributions will be small and have few serious consequences. For mature systems with large underfundings, however, the consequences can be significant. As retirees claim their promised pensions and the unfunded liability falls due, either taxes and contributions must rise, or services decline, or pensions must go unpaid. Either way, someone-- current residents, current public employees, or retirees--will bear an unexpected burden. If the liability is large enough, it may even precipitate a fiscal crisis in the public budget as a whole.[2] The one possible "winner" when public pensions go unfunded are earlier taxpayers who have left the jurisdiction and who did not contribute to the pension fund when the now retired public employees were providing services. Once we realize that public workers are paid a wage _and_ a pension for their efforts, it is clear that these prior taxpayers have not paid the full cost of the labor services received. Unfunded pensions can act as a _de facto_ subsidy from the current residents and/or retirees to the prior taxpayers who long ago may have left the state or locality. This implicit subsidy from underfunded pensions may seem unfair, may precipitate a wider fiscal collapse, and, like most unintended subsidies, may lead to a serious misallocation of public resources (see Inman (1982)). This paper seeks to identify the extent of pension underfundings for a major class of public employees--teachers--as a first step to avoiding these unhappy consequences.

Section II outlines the methodology used to estimate teacher pension underfundings. The approach is econometric, rather than actuarial. The analysis seeks to detail recent trends in pension funding for the major state and local teacher and teacher-related pensions plans; a detailed actuarial analysis of each plan for each year is not possible. I have adopted an alternative research strategy. I first specify--using the theoretical work of Ehrenberg (1980) and Winklevoss (1977)--and then _econometrically_ estimate--using the actuarially-based measures of underfunding in Arnold (1981)--a pension underfunding equation for state-local teacher and teacher-related pensions plans. This resulting equation correlates underfundings to commonly observed financial statistics and plan attributes. In section III, the estimated underfunding model is used to predict underfundings for major state-local teacher plans for the period 1971-80, given the plans' actual financial data and plan attributes for those years. The concluding Section IV summarizes the results and comments briefly on their policy implications.

II. An Econometric Approach to Estimating Pension Underfundings

A public pension is considered underfunded when assets currently held by the pension plan plus the discounted present value of future employee and employer (i.e., taxpayer) contributions are less than the discounted present value of all promised annuity (i.e., annual pension benefits) payments. Public employee pensions are defined benefit pensions in which workers are promised a fixed fraction, called the replacement rate, of some (usually three to five years) average of their pre-retirement income. This fraction is calculated as the product of the annual benefit accrual rate (typically .02/year) times the number of years in service. Thus employees with 25 years of service will receive 50 percent (25 x .02) of their average pre-retirement income as their retirement annuity. To fund this annuity, the employer-taxpayers may either wait until the employee retires and then pay taxes at that time to cover each year's promised pension, or the taxpayers can set aside a smaller nominal sum each year in a pension account to earn interest so that the accumulated principal and interest will be sufficient to cover the promised annuity stream when the workers retire. This second strategy is called full funding; the first strategy is called "pay-as-you-go."[3]

To employ the full funding strategy it is necessary to estimate the number of workers who will retire in each future year, how long they will live once retired, their average pre-retirement wage, and the length of job tenure before retirement. This information is sufficient to calculate the future stream of promised annuities. Given an estimate of market interest rates, the required annual contribution can be calculated which will be sufficient to fully fund these future pensions obligations. These annual contributions are called the normal costs of the pension plan. Typically, both taxpayers and public employees will contribute to meet normal costs; contributions are generally calculated as a percent of the current public employee wagebill (e.g., 10 percent of wages). This percentage is called the contribution rate. If past contributions which are accumulating as plan assets fall short of the full-funding levels, an unfunded pension liability will arise. To cover these past shortfalls--often called the plan's supplemental liability-- added contributions above normal costs are needed. These additional contributions are called the plan's supplemental costs and are usually calculated so as to cover the plan's unfunded liability gradually over a thirty to forty year period. It is our task here to approximate these unfunded pensions liabilities for the major pensions plans which support retired teachers using a consistent methodology which will permit across state and time comparisions.

Clearly it is not possible to do a detailed actuarial analysis of each state pension plan for each sample year. I have therefore developed an approximation which builds upon the earlier conceptual work of Ehrenberg (1980) and Winklevoss (1977) and the careful empirical analysis of state plans for the fiscal year 1978-79 by Arnold (1981). First, a specification of pension underfundings is developed for a typical defined-benefit public employee pension plan. Second, the specification is generalized to allow for the unique features of individual pension plans. Third, the implied "actuarial" parameters of the underfunding model are estimated econometrically using Arnold's estimates of pension underfundings. The data base is supplemented by plan characteristics abstracted from state pension legislation. Fourth, using a statistically preferred underfunding model and available pension plan data, predicted levels of plan underfundings are calculated for each state and for selected local plans for each year for the decade, 1971-1980.

At any point in time, a typical public employee pension plan's liabilities (L) will equal the difference between the discounted present value of promised benefits (PVB) less the discounted present value of all future contributions from taxpayers and employees (PVC): L = PVB - PVC. The liability not offset by existing plan assets (A) is called the plan's unfunded liability (U): U = L - A. Our task is to approximate U. To do so for a typical pension plan, I shall assume: (i) a constant flow of (n) new employees each period who exhibit a constant quit rate (q) and a constant mortality rate (δ) over an employment period of R years (i.e., mandatory retirement is also assumed); (ii) a fixed contribution rate (c) of wages; (iii) an annual growth in employee wages of g+h, where g reflects growth due to worker experience and h reflects the inflation growth in wages; (iv) a constant and uniform replacement rate (b) which when multiplied by the worker's final wage (w^F) defines the worker's annual pension; and (v) a constant cost of living adjustment (COLA) to the annual pension of rate (θ) times the inflation rate (p). The analysis will discount all nominal benefits and contributions at a nominal interest rate (r). Under these assumptions:

$$(1)\quad PVB = \int_{o}^{\infty} B(t)e^{-rt}dt \quad \text{and} \quad PVC = \int_{o}^{\infty} C(t)e^{-rt}dt,$$

where B(t) equals aggregate pension benefits paid in year t and C(t) equals aggregate contributions received in year t. The current period date of evaluation is denoted by the index o and an infinite plan horizon is assumed.

The future wage of any worker at time v, who has been in the plan for s years, will be:

$$(2)\quad w(s,v) = w_o\ e^{hv}\ e^{gs},$$

where w_o is the initial period wage. The final retirement wage of a worker who started in the system at time (v-s) and has been in the system for R years wil be:

$$(3)\quad w^F(s,v) = \left[w_o e^{(v-s)h}\right] e^{hR}\ e^{gR} = w_o\ e^{gR}\ e^{h(v-s+R)}\ .$$

PVC is approximated in two steps. First, contributions into the system at any time v are estimated by :

$$(4)\quad C(v) = \int_{o}^{R} cw(s,v)ne^{-(q+\delta)s}ds,$$

where c is the fixed contribution rate from wages, w(s,v) is the wage of a worker with s years of experience in year v, and $ne^{-(q+\delta)s}$ is the number of workers of s years of experience who have survived (quits and mortality) to time v. Contributions are aggregated over all workers from those just starting (s=o) to those just retiring (s=R). Second, the present value of these annual contributions are calculated by discounting by r summed over all time:

$$(5)\quad PVC = \int_o^{\infty} C(v)e^{-rv}dv.$$

Solving equations (4) and (5) gives the following specifications for PVC.

$$(6)\quad PVC = \frac{(cw_o n)\ (1-e^{-(q+\delta-g)R})}{(r-h)(q+\delta-g)}\ .$$

PVB is also approximated in two steps. First, total retirement benefits paid in year v is estimated by:

$$(7)\quad B(v)= \int_R^{\infty} bw^F\ (s,v)e^{\theta p(s-R)}\ ne^{-(q+\delta)R}\ e^{-\delta(s-R)}ds\ ,$$

where b is the replacement rate applied to the final wages of workers of age s in year v adjusted for inflation protection in the post-retirement years at the rate θp ($w^F(s,v)e^{\theta p(s-R)}$, s>R). Benefits paid in year v are the sum of benefits paid to all workers who have survived to retirement and are still alive ($ne^{-(q+\delta)R}\ e^{-\delta(s-R)}$). Second, the present value of these annual benefit payments are calculated by discounting at r over all time:

$$(8)\quad PVB= \int_o^{\infty} B(v)e^{-rv}dv.$$

Solving equations (7) and (8) gives the following specifications for PVB:

$$(9) \quad PVB = \frac{(bw_o n)\,(e^{(g-(q+\delta))R})}{(h+\delta-\theta\rho)(r-h)} \, .$$

The unfunded liability of a pension plan is defined as $U = L - A$. Noting that $L = PVB - PVC$, U can now be specified as:

$$(10) \quad U = \frac{(bw_o n)e^{(g-(q+\delta))R}}{(r-h)(h+\delta-\theta p)} - \frac{(cw_o n)(1-e^{-(q+\delta-g)R})}{(r-h)(q+\delta-g)} - A$$

using the definitions of PVC and PVB in equations (6) and (9) respectively. Equation (10) can be simplified to:

$$(10') \quad U = \left(\frac{1}{r-h}\right)B_o - \left(\frac{\Delta}{r-h}\right)(c/b)B_o - A \quad ,$$

where,

$$B_o = bw_o\, ne^{(g-(q+\delta))R} / (h+\delta-\theta p),$$

and measures benefits paid to today's retirees,[4] and where Δ defined as:

$$\Delta = \frac{(h+\delta-\theta p)}{(q+\delta-g)}\,(e^{(q+\delta-g)R}-1),$$

and (r-h) are "actuarial constants" dependent upon actuarial assumptions. Equation (10') defines the level of today's (period o) unfunded liability for a typical public employee pension plan.

To move from a typical to an actual pension plan requires a specification of plan-specific features. These include the level of benefits paid today (B_o), the plan's actual contribution rate (c) and replacement rate (b), the level of the plan's accumulated assets (A), the plan's rate of inflation protection (θ), and the plan's number of years of service before benefits are paid (R).[5] The other parameters of (10') -- r, h, δ, q, g, and p -- are actuarial parameters and, for the purposes of comparing plan underfundings, are assumed to be equal across pension plans.[6]

In fact, equation (10') may not capture all the plan-specific features which distinguish one teacher pension system from another. Assets, for example, may be held in different portfolios which earn different rates of return. Contributions may vary in some years from the anticipated rate c because of short-term political decisions or unexpected fluctuations in state revenues or non-pension expenditures. In addition, the relationship in (10') is based on the assumption that the plan is in a steady-state; in fact, the plan may be in an expansion or contraction phase. Finally, teacher-only pension plans may be differentially favored or disfavored in plan funding or portfolio performance compared to those pension plans which include teachers with all other public employees.

These observations suggest that the basic model in (10') should be extended to include a fixed component dependent upon plan type ($\emptyset=\emptyset_o+\emptyset_1$(T=1 if teacher only plan, 0 otherwise)), variations in the estimated actuarial constants because of variable plan growth,[7] and, finally a stochastic component related to the level of plan assets ($\varepsilon = \gamma A$, where $E(\varepsilon) = AE(\gamma)=0$, and $\sigma_\varepsilon^2 = A^2 \sigma_\gamma^2$).

Equation (11) allows for these extensions:

$$(11) \quad U = \emptyset_o + \emptyset_1 T + \emptyset_2 m + (\frac{\mu(m)}{r-h})B_o +$$

$$(\frac{-\Delta \quad \mu(m)}{r-h})(c/b)(B_o)$$

$$- A + \gamma A,$$

where m is the recent rate of growth in plan membership. Dividing by A and rearranging slightly gives the specification most suitable for estimation:

$$(11') \quad (1+U/A) = \emptyset_o(1/A) + \emptyset_1(T/A) + \emptyset_2(m/A) +$$

$$(-\mu(m)/r-h)(B_o/A) + (-\Delta\mu(m)/r-h)(c/b)(B_o/A)$$

$$+ \gamma.$$

To estimate the effects of plan growth on the actuarial parameters (r-h) and Δ, a simple interactive specification of the form $\mu(m) = 1 + \mu m$ will be tried; when $\mu=0$ the actuarial parameters are not significantly affected by the observed variations in m. Finally, as Δ varies across pension plans as years to retirement (R) and COLA protection ($\theta\rho$) vary, I have approximated the steady-state specification of Δ (see above at equation 10′) by the second-order Taylor series expansion about a fixed $\bar{\Delta}$:

$$\Delta = \bar{\Delta} + \Delta_1(\theta p - \overline{\theta p}) + \Delta_2(R - \bar{R}) + \Delta_3(\theta p - \overline{\theta p})(R-\bar{R})$$

$$+ \Delta_4(\theta p - \overline{\theta p})^2 + \Delta_5(R - \bar{R})^2.$$

Substituting this approximation for Δ into (11′) gives the final specification used in the econometric analysis.[8]

Table 1 summarizes the econometric estimation of the underfunding model estimated from a sample of thirty-seven pension plans for the fiscal year 1978-79 for which full underfunding and plan attribute data were available.[9] Pension underfundings (variable U) are from Arnold (1981) and measure plan continuation liability, the appropriate measure of U under the politically plausible assumption that existing pensions to current employees will not be terminated. (See Bulow (1982) for arguments which favor using plan termination liability; Bulow, however, is focusing on private pensions.) Data for plan assets (A), benefits (B), and membership (to calculate m) are from the Census of Government publication, Finances of State and Local Employee Retirement Systems (1978-79). Data for each plan's required contribution (c) benefit replacement rate (b), age of retirement, and COLA (θ) were obtained from state pension laws. In calculating the benefit replacement rate allowance was made for whether the plan was or was not integrated into social security. If full or partial integration is allowed, I assumed social security replaced 27% of employees pre-retirement wages when calculating b.[10] In states, which do not explicity allow for COLA protection, but do grant periodic adjustments, I followed Arnold's (1981) assumption and set $\theta = .5$. In calculating years of service (R), I assumed the typical teacher begins service at age 30 and works without interruption to the age of retirement.

Estimated equation (1) in Table 1 corresponds to the basic underfunding model of (10′) above, extended to permit a stochastic error structure of the form, $\varepsilon = \gamma A$. The coefficient estimates for this simple model imply values for the actuarial parameters of $(r-h) = .022$ $(= 1/45.65)$ and $\Delta = 2.69$ $(=-(-122.82/45.65)$. Both numbers are

Table 1
Correlates of Teacher Pension Underfundings
(Dependent Variable 1 + U/A)

Estimated Actuarial Parameters	(1)	(2)	(3)	(4)	(5)	(6)
ϕ_o	= 0	64689 (302950)	-184220 (290680)	-204730 (278980)	-157990 (267210)	= 0
ϕ_1	= 0	16452 (257350)	162560 (269830)	185480 (255980)	117250 (231740)	= 0
ϕ_2	= 0	2.597×10^6 $(2.113 \times 10^6))$	3.097×10^6 (1.962×10^6)	3.221×10^6* (1.893×10^6)	2.972×10^6* (1.816×10^6)	2.113×10^6* (1.043×10^6)
(1/r-h)	45.65* (8.14)	44.23* (9.09)	45.04* (8.81)	45.84* (8.31)	41.16* (6.88)	39.61* (6.03)
($-\Delta$/r-h)	-122.82 (78.77)	-146.81* (84.57)	n.a	n.a	n.a.	n.a.
($-\bar{\Delta}$/r-h)	n.a.	n.a.	-95.84 (121.27)	-109.44 (111.79)	= 0	= 0
($-\Delta_1$/r-h)	n.a.	n.a.	521.90 (3879.00)	1576.70 (2022.10)	1402.80* (791.67)	1417.30* (770.70)
($-\Delta_2$/r-h)	n.a.	n.a.	-46.62* (28.13)	-46.97* (27.65)	-63.97 (19.24)	-61.28* (17.57)
($-\Delta_3$/r-h)	n.a.	n.a.	78.26 (383.93)	20.06 (333.80)	= 0	= 0
($-\Delta_4$/r-h)	n.a.	n.a.	10559 (32932)	= 0	= 0	= 0
($-\Delta_5$/r-h)	n.a.	n.a.	5.04* (1.98)	5.12* (1.93)	6.29* (1.56)	5.98* (1.42)
$\bar{R}^2$	.331	.391	.528	.543	.556	.579
SEE (U)	2.29×10^6	2.16×10^6	1.92×10^6	1.93×10^6	1.79×10^6	1.73×10^6

Notes to Table 1

n.a. = Not applicable to specification being estimated.

0 = Coefficient is constrained to equal zero, *a priori.*

* = Estimated coefficient is statistically different from zero at the 10% level or better.

ϕ_0 = Estimated coefficient for the variable (1/A).

ϕ_1 = Estimated coefficient for the variable (T/A).

ϕ_2 = Estimated coefficient for the variable (m/A).

(1/r-h) = Estimated coefficient for the variable (B_0/A).

$(-\Delta/r-h)$ = Estimated coefficient for the variable $(c/b)(B_0/A)$.

$(-\bar{\Delta}/r-h)$ = Estimated coefficient for the variable $(c/b)(B_0/A)$ when Taylor series approximation for Δ is employed.

$(-\Delta_1/r-h)$ = Estimated coefficient for the variable $(c/b)(B_0/A)(\theta p - \overline{\theta p})$; $\overline{\theta p} = 0$.

$(-\Delta_2/r-h)$ = Estimated coefficient for the variable $(c/b)(B_0/A)(R-\bar{R})$; $\bar{R} = 24$.

$(-\Delta_3/r-h)$ = Estimated coefficient for the variable $(c/b)(B_0/A)(\theta p - \overline{\theta p})(R-\bar{R})$; $\overline{\theta p} = 0$ and $\bar{R} = 24$.

$(-\Delta_4/r-h)$ = Estimated coefficient for the variable $(c/b)(B_0/A)(\theta p - \overline{\theta p})^2$; $\overline{\theta p} = 0$.

$(-\Delta_5/r-h)$ = Estimated coefficient for the variable $(c/b)(B_0/A)(R-\bar{R})^2$; $\bar{R} = 24$.

plausible and suggest even the simple model has captured the essence of the actuarial calculation of U.

Estimated equation (2) extends the basic underfunding model by permitting a "fixed effect" to underfunding of $\phi_0 + \phi_1 T + \phi_2 m$, where T=1 if the pension plan applies to teachers only, 0 otherwise, and m is the rate of growth of plan membership from 1971 to 1980. The results reveal no significant fixed effect difference on underfundings between teacher and general pension plans. This is perhaps not surprising as most states now jointly administer teacher and general employee plans. However, the level of underfundings in teacher and general plans can still differ as plan attributes -- B,A,c,b,θp, and R -- differ; all we observe from the "fixed effect" in equation (2) is that there is no administrative bias in favor of, or against, teacher-only plans. We do observe an almost significant effect of recent membership growth on underfundings, however. The fixed effect of m on underfundings is positive and becomes statistically significant in later specifications. The positive effect of m on underfundings is plausible; it implies new contributions in high growth plans have lagged the new increases in liabilities. In results not reported in Table 1, I also tested for the the effect of m on the actuarial constants, (r-h) and Δ, as defined by estimated "slope" coefficients. Multicollinarity prevented a precise identification of the effects of m on the relevant slope coefficients; a simplier test that low growth and high growth ($m \geq .03$ per annum) plans had equal actuarial coefficients could not be rejected in the full model.[11] Thus in the work which follows only the intercept, or fixed effect, of plan growth on underfunding is considered.

Estimated equation (3) introduces the Taylor series approximation for the actuarial constant, Δ. The more elaborate specification for Δ has no significant consequences for our estimate of (r-h), again it equals .022. The individual coefficients of the approximation $(\bar{\Delta},\Delta_1,\ldots\Delta_5)$ generally have plausible signs (see fn. 8 above), though they are not always precisely estimated. The implied value of Δ is again about 3 for the average sample plan. Estimated equation (4) is a simple extension of equation (3) with the a priori constraint that $\Delta_4 = 0$ (again see fn. 8) imposed before estimation. Equations (3) and (4) are virtually identical.

Estimated equations (5) and (6) impose additional structure on the estimation in hopes of improving the model's overall predictive performance. Variables whose estimated coefficients are less than their standard errors have their coefficients constrained to be 0, first for the slope coefficients which define Δ (equation 5) and then for the slope and intercept coefficients (equation 6). As expected the R^2 adjusted for degress of freedom ($\bar{R}^2$ in Table 1) rises with each additional restriction.

Since our central concern is the level of underfundings, the preferred pension funding equation is that equation which minimizes the standard error of estimate of the aggregate level of pension underfunding, U (assuming quadratic loss). The standard error of U (SEE (U)) for each equation for our sample is reported in Table 1. Estimated equation (6) is the preferred pension underfunding equation by the criterion of minimizing SEE (U); it will be the basis for estimating the funding status of teachers' pension plans for the period 1971-1980.

III. The Estimated Funding Status of Teachers' Pensions

Tables 2-4 summarize the results of the predicted funding status of U.S. teacher pension plans for the decade 1971-1980.[12] Tables 2 and 3 list the means across state plans and local plans respectively for each year for four summary measures of underfunding: (i) estimated underfundings per (state or local) resident; (ii) the ratio of estimated underfundings to total plan liability; (iii) estimated underfundings per plan member; and (iv) the ratio of estimated underfundings per resident to income per resident. Table 4 illustrates the relative dispersion in underfundings per resident across the best and worst funded plans for both states and localities.

The results in Tables 2 and 3 shows a general upward trend in estimated underfundings of teachers' pensions. Average underfundings per capita measured in constant (1967) dollars have risen by 65% in all state plans from 1971-1980 and by approximately 33% for the full sample of local plans from 1974 to 1980. General (all public employees, including teachers) plans are less well funded than either state or local teacher-only plans. As a general rule-of-thumb public employee pensions are considered well funded when the underfunding to liability ratio (or alternatively, the asset to liability ratio) is less than .20 (greater than .8); see for example, Tilove (1976). Clearly, the majority of the plans considered here do not meet this standard; the underfunding/liability ratios in Tables 2 and 3 never fall below .5. Further, the trend has been upward for all plans, rising most sharply for the full sample of local plans. Underfundings have also worsened from the perspective of plan membership; underfundings/member in real (1967) dollars have risen for all plan types. Teachers are significantly more at risk in teacher-only plans

Table 2

Funding Status for Teachers' Pensions: State Plans

Year/Plan	Mean State Underfunding/Resident			Mean State Underfunding/Liability			Mean State Underfunding/Member			Mean State Underfunding/Income		
	All	General	Teacher	All	General	Teacher	All	General	Teacher	All	General	Teacher
1971*	$190.48	$300.69	$141.86	.567	.610	.549	$7912	$6875	$8370	.071	.113	.053
1972*	$211.82	$313.07	$158.04	.570	.614	.547	$8864	$9040	$8771	.073	.109	.055
1973	$239.47	$341.93	$181.84	.599	.645	.573	$9006	$7954	$9598	.081	.115	.061
1974	$256.72	$348.25	$200.63	.636	.657	.623	$9333	$7247	$10611	.088	.121	.068
1975	$264.38	$353.46	$209.78	.621	.641	.609	$9676	$7436	$11049	.089	.121	.069
1976	$287.62	$398.29	$213.12	.622	.648	.582	$10164	$7953	$11084	.094	.132	.068
1977	$295.99	$411.84	$217.53	.623	.642	.579	$10549	$8004	$11624	.094	.133	.067
1978	$300.61	$417.78	$228.78	.621	.647	.605	$10670	$7999	$12308	.093	.134	.069
1979	$315.33	$447.52	$234.31	.637	.679	.611	$11011	$8759	$12391	.098	.143	.070
1980	$314.54	$424.66	$247.04	.623	.654	.603	$11324	$8682	$12941	.099	.139	.075

* Results exclude Delaware for reasons of insufficient data. Underfunding per member and underfunding pre resident are both measured in 1967 dollars.

Table 3
Funding Status of Teachers' Pensions: Local Plans

	Mean Local Underfunding/ Resident	Mean Local Underfunding/ Liability	Mean Local Underfunding/ Member	Mean Local Underfunding/ Income
1971*	$163.09	.658	$15736	.060
1972*	$186.50	.627	$16748	.064
1973*	$184.62	.628	$16216	.065
1974	$117.19	.516	$10067	.042
1975	$119.57	.641	$ 9794	.042
1976	$133.70	.654	$10705	.044
1977	$147.94	.655	$10694	.048
1978	$164.40	.667	$11948	.050
1979	$156.44	.657	$11273	.050
1980	$155.55	.657	$11253	.051

* 1971-1973 results are for a limited sample of local teacher plans. Only local teacher-only plans are included. Local teacher plans included in the analysis are Washington, D.C. (1971-1980), Chicago (1971-1980), Duluth (1971-1980), Minneapolis (1971-1980), Boston (1971-1980), New York City (1971-1980), Portland (1971-1980), Milwaukee (1971-1980), St. Louis (1972-1980), Fulton Co. Ga., (1973-1980), Des Moines (1973-1980), Wichita (1973-1980), Kansas City, Mo.(1973-1980), Denver (1973-1980), Omaha (1973-1980), Detroit (1974-1980), Arlington, Va. (1977-1980). Underfunding per member and underfunding per resident are both measured in 1967 dollars.

than in general public employee plans. These levels of underfundings per member equal from 50 to 70 percent of the present value of each member's promised pension annuity (PVB in equation (9) above), again measured in 1967 dollars.[13] Finally, the relative burden of underfundings on residential incomes is also rising. Public debt will not stand as a serious long-run economic threat if taxpayers' incomes grow as fast or faster than the growth in the debt itself (Feldstein, 1976). As Tables 2 and 3 make clear, however, this has not been the case for public debt from the underfunding of teacher pensions.

The causes of the observed increases in teacher pension underfundings are not difficult to find. While the average rate of contributions as a fraction of payroll has risen slightly over the decade, benefits paid to retirees have risen substantially. The average benefit accrual rate has risen from .015 per service year in 1971 to .018 per service year in 1980, implying an increase in the promised annual annuity of about 7.5 percent for an employee with 25 years of service (.075 = .018 x 25 - .015 x 25). Of far more significance, however, has been the growth in the use of COLA protection. The average rate of COLA protection (θp) has increased from .021 in 1971 to .048 by 1980 in state plans and from .01 to .025 in local plans. The large increase can be attributed to the introduction of COLA provisions generally and to the high rates of inflation experienced in the later years of the decade.

Not surprisingly, those state and local plans which have been most generous in benefits are generally the plans which face the highest level of underfundings. Table 4 summarizes the levels of underfundings per capita for the worst-funded and the best-funded of

Table 4
Dispersion in Teacher Pension Underfundings

	Mean Underfundings/Resident*			
	State Plans		Local Plans	
	10 Worst	10 Best	5 Worst	5 Best
1971	$454.57	$31.52	–	–
1972	$474.61	$33.37	–	–
1973	$509.59	$45.03	–	–
1974	$532.25	$59.91	$315.04	-$39.89
1975	$532.28	$69.56	$337.65	-$56.95
1976	$565.70	$62.54	$372.87	-$57.76
1977	$585.25	$65.09	$418.31	-$51.08
1978	$582.89	$78.80	$465.01	-$44.48
1979	$643.79	$91.87	$393.64	-$42.11
1980	$652.18	$84.60	$428.48	-$33.27

* 1967 Dollars

these state and local plans. The state plans in Alaska (teacher), Hawaii (general), Idaho (general), Maine (general), Massachusetts (teacher), Mississippi (general), West Virginia (teacher), and Wyoming (general) were consistently poorly funded while the state plans in Minnesota (teacher), Missouri (teacher), New Hampshire (teacher), Texas (teacher), and Wisconsin (teacher) were largely well-funded over the decade. The local, teacher-only plans in Denver, Kansas City, Mo., St. Louis, and Wichita were consistently well-funded, while those in Washington, D.C., New York City, Detroit, and Chicago were generally poorly funded.[14] It is instructive to note that the worst funded plans are generally found in our poorer rural states and in the more industrialized cities. Yet importantly, not all rural states or poor cities have poorly funded plans; New Hampshire, Wisconsin and St. Louis, for example, make the well-funded lists.

Tables 2-4 take the perspective of the individual states and present averges of state averages (e.g., the average of state underfunding per resident). However, if our poorest funded plans are in our largest states, national underfundings per resident will be larger than the state and local averages presented above. It is instructive for purposes of comparisons to other measures of public debt to calculate total underfundings across all the teacher and teacher-related plans considered here; see Table 5. In 1980, for example, the estimated underfunding of all sample plans was $175.03 billion or $775/capita (1967 dollars). This can be compared to gross federal debt in 1980 of $371.67 billion (1967 dollars). Further a recent study of the federal civil service pension system (Leonard, 1984) has estimated that plan's underfunded liability to be $220 billion in 1981 (again measured in 1967 dollars) When compared to

Table 5
National Underfundings of Teacher-Related Pensions*

	National Teacher-Related Pension Underfundings	Gross Federal Debt**
1971	$ 48.649 billion	$337.59 billion
1972	$ 50.491 billion	$349.00 billion
1973	$ 71.384 billion	$351.91 billion
1974	$ 83.878 billion	$329.18 billion
1975	$ 94.353 billion	$337.53 billion
1976	$105.672 billion	$370.62 billion
1977	$117.311 billion	$390.69 billion
1978	$134.996 billion	$399.39 billion
1979	$157.259 billion	$383.53 billion
1980	$175.031 billion	$371.67 billion

*Both debt series are measured in 1967 dollars.
**Source: Economic Report of the President, 1984, pp 282 and 306.

these other debt levels, it is clear teacher and teacher-related public pension plans must be included as a major contributor to any aggregate measure of national public debt.

While the estimated levels of underfundings observed here are troubling, they are not unmanageable. For most state-local teacher pension plans, the benefit explosion of the past decade is behind us and is unlikely to be seen again in the near future. Most states have adopted COLA provisions and inflation is likely to be reasonably managed in the future. Three groups may be asked to pay: current teachers via benefit reductions, current taxpayers via tax increases, or school-aged children via reduced school services. In 1980, the stock of underfundings per member in the average state-local teacher-related pension plan totaled $11320 per plan member (1967 dollars) or approximately 60 percent of each current teacher's anticipated stock of pension wealth (PVB). To ask current teachers to pay the entire burden would be a considerable hardship, particularly for teachers just now nearing retirement and unable to adjust their private savings. Were taxpayers to cover 1980's pension debts, a one-time tax of approximately 3.3% on average resident income would be sufficient to cover past underfundings in the average state-local plan (.033 = $303.15 of underfundings/resident divided by $9186 of income/resident). Were school children to cover 1980's debts by sacrificing school expenditures, a one-time sacrifice of $560/public school enrollee (1967 dollars) or 60 percent of that year's average expenditure per enrollee would be sufficient. Of course, gradual repayment is possible. If we amortize the average state's 1980 pension debt over 30 years at an assumed 10 percent interest rate, a3/10's of 1 percent annual increase in resident income taxes or a 5.5 percent fall in annual school expenditures devoted to education will be required.

IV. Conclusions

The funding status of public employee pensions has become an issue of increasing public policy concern.

Significantly underfunded public pensions are a possible source of economic inefficiency and may have unattractive implications for economic equity as well. This paper provides one estimate of the funding status of teacher pensions in the United States and finds a potentially significant level of underfunding in the average state and local plan.

Many state and local plans--generally found in older, more industrialized cities or in poorer rural states--have underfundings which exceed $500/resident, measured in 1967 dollars.

A balanced strategy of gradual debt reduction is still possible. Modest tax increases (perhaps 3/10's of 1% of resident income) will cover the interest costs of past pension debt and permit gradual repayment, without requiring benefit reductions to current teachers or service cutbacks for students. But such a policy must be considered in a wider context. Underfunded teacher pensions are only one source of our nation's growing public debt. Federal government budgets, social security, federal employees' pensions, and other state-local employee pensions are all underfunded. If considered together, the tax increases or benefits and service reductions needed to service this debt may be sizeable indeed. Not all of the burden of past public debt need fall on taxpayers; current public employees and service beneficaries (e.g., school age children) may be asked to share in these costs as well.

We should note that in one happy set of circumstances these pension underfundings will not pose an economic problem. To the extent that taxpayers and/or teachers have correctly anticipated these underfundings they will have made fully compensating adjustments in their own savings behavior in expectation of larger future taxes or smaller pension annuities. Further, the increased savings would have been made possible by dollars given to current taxpayers by past taxpayers in the form of lower land prices (the "capitalization" of underfundings) or by dollars given to teachers as higher wage payments (the "compensating wage differential" for underfundings). In either case, the private market will have fully corrected for the failures of the public sector. The evidence for this hypothesis is mixed at best, however, and there are good reasons to be skeptical.[15]

Footnotes

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[1] See for example, Aronson (1975), Munnell and Connolly (1976), House of Representatives (1978), Inman (1980), Pease (1980), Arnold (1981, 1982) and the Urban Institute (1981).

[2] It has been argued that the New York fiscal crisis was in part a fall-out of growing local pension costs; see Morris (1980).

[3] There are special circumstances when the "pay-as-you-go" strategy may be preferred to the full-funding strategy; see Samuelson (1975), Arnott and Gersovitz (1980), or Merton (1983). Generally, however, full-funding insures a more efficient allocation of societal resources (Feldstein (1976) and Inman (1982)) as well as protects workers' pensions. I shall assume full-funding is the desired standard in the analysis which follows.

[4] This result follows from the solution to equation (7) for the period v=0.

[5] The formal analysis ingores variation in vesting provisions across pension plans. Vesting defines the minimal number of years of service before pension rights are secure. The greater the number of years to vesting, the lower should be the plan's unfunded liability since fewer workers are likely to qualify for pension benefits. Vesting differences will have to be substantial, however, before a sizable effect on underfundings will be observed; see, for example, Bulow (1982). In our sample, most plans vest their members within five to fifteen years and these differences have only small effects on underfunding estimates; see Arnold (1982) summarized in Kotlikoff and Smith (1983, section 7.7).

[6] This assumption is appropriate given my decision to use the Arnold data base. Arnold (1981) applies the same values of r, h, δ, q, g, and p to each plan when estimating that plan's unfunded liability. Thus, in my econometric analysis these parameters are, by definition, constants. If estimates of U are based on different values of r, h, δ, q, g, or p, then the regression analysis used to describe differences in U must allow for variations in these parameters.

It should be noted that Arnold (1981) did test for differences in mortality rates (δ) across states and quit rates (q) across states and could not reject the null hypothesis of equality. The nominal interest r and the inflation rate p are national and thus should be uniform across all plans in any year. The assumption of similar wage structures (g) and nominal wage growth (h) across plans also seems reasonable as public employee bargaining is now commonplace.

[7] The formula outlined in equation (10) above is not precisely consistent with actuarial principles of pension accounting as used by Arnold (1981) and others. Specifically, as specified the calculation of PVB and PVC assume current taxpayers will be responsible for <u>all future</u> employees benefits above all future planned contributions. The usual practice when calculating U is to make current taxpayers responsible only for <u>current</u> employee benefits. It is possible to show that the algorithm in (10) will give a biased (likely upward) estimate of this "true" measure of underfunding. The bias is likely to be greatest for plans with high rates of membership growth. Permitting plan growth to influence both the intercept (a fixed effect) and the slope coefficients in an estimated underfunding equation should minimize the bias from employing the specification in (10); see Ehrenberg (1980, fn. 12).

[8] The coefficients $\Delta_1 \ldots \Delta_5$ have specific interpretations as first and second derivatives of the actuarial constant Δ with respect to the COLA rate, θp, and the years of service, R. For plausible values of the other actuarial parameters in Δ, we can predict the likely signs of $\Delta_1 \ldots \Delta_5$. For example, if $h + \delta > \theta p$ and $q + \delta > g$, then $\Delta_1 = \partial\Delta/\partial(\theta p) < 0$, $\Delta_2 = \partial\Delta/\partial R > 0$, $\Delta_3 = .5\partial\Delta/\partial(\theta p)\partial R < 0$, $\Delta_4 = .5\partial^2\Delta/\partial(\theta p)^2 = 0$, and $\Delta_5 = .5\partial^2\Delta/\partial^2 R > 0$.

[9] All local teacher plans and thirteen state plans had to be excluded from the regression analysis for reasons of incomplete

estimates of U for the sample year, 1978-79. The excluded states were Alabama, Georgia, Indiana, Maryland, Massachusetts, Michigan, New Hampshire, Ohio, Oklahoma, Texas, Utah, Washington, and Wisconsin.

[10] See Boskin and Shoven (1984), Table 3. For the simulation of underfunding in years other then 1978-79, the social security replacement rate was adjusted to allow for the actual historical experience; see Boskin and Shoven (1984), Table 3.

[11] The sample was divided into low growth and high growth plans according to the criteria of whether plan membership from 1971-80 grew less than, or greater than, 3% per year. For estimated equations (1) the value of F for the null hypothesis of no difference was F (2,33) = 6.32; we can reject the null hypothesis of no difference at a 5% level of confidence. For the full model specifications in equations (2) - (6), however, the F statistic for the null hypothesis of no difference did not reject the hypothesis; F (5,27) = 1.831 for equation (2), F (10,17) = .706 for equation (3), F (9,19) = .672 for equation (4), F (7,23) = 1.049 for equation (5), and F (5,27) = 1.326 for equation (6). Since m is included as a fixed effect in equations (2) - (6), the test applied to those equations is for slope effects only.

[12] There is always a danger in prediction of extrapolating to circumstances outside the original sample period. This is not a serious concern for our study for the simple reason that we are not estimating a behavioral relationship to predict behavior, but rather,

an accounting rule to help us organize financial data. The accounting rule is valid across all periods of our sample, so our estimate of that rule is also valid across all sample periods.

[13] PVB can be approximated from equation (9) as $B_o/(r-h)$. B_o is a plan's current payments to retirees and $(r-h)$ is $\simeq .022$.

[14] A data appendix giving estimated underfundings for each plan for each year is available from the author upon request.

[15] See, for example, Epple and Schipper (1981), Inman (1982), and Smith (1981,1983). My skeptism is prompted by the simple fact that after five years of research into matters of public pension policy, only this year did I bother to look up my own community's unfunded liability. Do you know your community's unfunded liability? Perhaps we are the infra-marginal homeowners?

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