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PEAKS, CLIFFS, AND VALLEYS: THE PECULIAR INCENTIVES IN TEACHER RETIREMENT SYSTEMS AND THEIR CONSEQUENCES FOR SCHOOL STAFFING

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Abstract

This article examines the pattern of incentives for work versus retirement in six state teacher pension systems. We do this by examining the annual accrual of pension wealth from an additional year of work over a teacher's career. Accrual of wealth is highly nonlinear and heavily loaded at arbitrary years that would normally be considered mid-career. One typical pattern exhibits low accrual in early years, accelerating in the mid- to late fifties, followed by dramatic decline or even negative returns in years that are relatively young for retirement. Key factors in the defined benefit formulas that drive such patterns are identified along with likely consequences for employee behavior. The authors examine efficiency and equity consequences of these systems as well as options for reform.

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1. INTRODUCTION

Pensions have long been an important part of compensation for teachers in public schools. Traditionally, it has been argued, salaries have been relatively low, but pension benefits have been relatively high for teachers and others who spend their careers in public service. This mix of current versus deferred income was rationalized by the contention that the public good was best served by the longevity of service that would be induced by these pension plans (NEA 1995).[1] In recent decades, however, evidence has grown that many of these plans, in both the private and the public sector, may actually have *shortened* rather than lengthened professional careers by encouraging early retirements.[2]

This highlights the growing disconnect between state teacher pension systems and the larger public discussion of pension and Social Security solvency in an era of longer life spans and the impending bulge of retirees (see, for example, Diamond and Orszag 2003; Kotlikoff and Burns 2004; Munnell and Sass 2008). Nearly all proposed remedies for fixing Social Security involve raising retirement ages as part of the menu. By contrast, there is little discussion of the incentives to retire even earlier in teaching; indeed, early retirement plans are commonplace in teaching, even as traditional pension plans are disappearing entirely in much of the private sector.

The cost side of employee benefits also affects labor markets by driving a wedge between the amount paid by employers and the take-home pay received by teachers. The sharp rise in that wedge due to employee health insurance costs is well documented. However, less well known are the growing costs and large unfunded liabilities for some teacher pension plans and virtually all retiree health insurance plans. In Ohio, for example, the combined contributions of teachers and school districts for retirement benefits have risen steadily from 10 percent in 1945 to 24 percent today. But even this large "tax wedge" falls short of what is needed, and pension officials are recommending a phased increase to 29 percent to shore up funding for pensions and retiree health benefits. At this level, retiree benefits for teachers and other professionals would be consuming well over $1,000 of the annual per student expenditures. The costs of school retiree benefits (including "legacy" costs from unfunded

1. As the National Education Association (NEA) report points out, however, this purpose has "been lost for many in the mists of time," and "many pension administrators would be hard-pressed to give an account of why their systems are structured as is except to say that 'the Legislature did it' or 'It is a result of bargaining'" (NEA 1995, p. 3).
2. Kotlikoff and Wise (1987) showed the incentives for early retirement in private defined benefit pension plans and argued that their spread in the postwar period contributed to declining labor force participation of older workers up to that time. More recently, Friedberg and Webb (2005) showed that the private sector shift toward defined contribution plans has contributed to the rise of retirement ages since the 1980s. With regard to teachers, Harris and Adams (2007) find considerably higher rates of labor force exit at ages 56–64 than in comparable professions as well as evidence that this is due to their pension coverage.

benefits for previous retirees) consume a sizable share of K–12 spending, similar to the benefit overhang of GM, Chrysler, and Ford, which finally forced them to overhaul their retiree benefits.[3]

As the costs of teacher retiree benefit systems receive more attention from policy makers, it is important to begin asking what effect these systems have on recruitment, retention, and workforce quality and whether these are efficient expenditures. A substantial literature in labor economics demonstrates that the incentives in pension systems matter, not only for the timing of retirement but for labor turnover and workforce quality (Friedberg and Webb 2005; Asch, Haider, and Zissimopoulos 2005; Ippolito 1997; Stock and Wise 1990). Unfortunately, little of this literature pertains to teacher pensions. While there have been many studies of the effect of current compensation on teacher turnover (e.g., Murnane and Olsen 1990; Stinebrickner 2001; Hanushek, Kain, and Rivkin 2004; Podgursky, Monroe, and Watson 2004), the econometric literature on teacher pensions is very slender. The only published econometric study to date is by Furgeson, Strauss, and Vogt (2006), who find that Pennsylvania teachers responded to pension incentives.[4]

In this article, we analyze the incentives embedded in teacher pension systems by examining the pattern of pension wealth accumulation over a teacher's career. As we shall see, these systems feature dramatic peaks, cliffs, and valleys in pension wealth accumulation that can distort career decisions—or penalize teachers for not adapting their plans to the system's benefit structure. In many states, teachers will accumulate little pension wealth until their early fifties, at which point they can suddenly reap large increases. But if they stay much beyond such a pension "peak" they can suffer declines in pension wealth, incurring a tax-like financial penalty for staying too long. This is one simple pattern with no compelling rationale, but systems can also exhibit even more peculiar accumulation patterns that reward or penalize teachers at seemingly arbitrarily chosen points in their career.

Our main contribution in this article is to illustrate graphically the peaks and valleys in pension wealth accumulation that operate over the course of a teacher's career in an illustrative set of six state systems. They are in contrast with the much smoother path of pension wealth accumulation under alternative professional pension plans, increasingly common in other sectors, that tie benefits more closely to contributions and that, as a result, provide more neutral incentives for career decisions.

3. The focus of this article is on the incentive structure of teacher retirement benefits and not their overall level. For a discussion of that issue, see Costrell and Podgursky (2009).
4. See also Brown 2008 for a study of teacher retirements in the Los Angeles (LA) Unified school district.

2. HOW TEACHER PENSIONS WORK

Public school teachers are almost universally covered by traditional defined benefit (DB) pension systems. We say "traditional" because these are the types of plans that were the norm in both the public and the private sector until recent decades. However, this is no longer the case in the private sector, where employers have shifted dramatically to 401(k)-type defined contribution (DC) systems and restructured their DB systems as well (more on this below).[5] In a traditional DB system, the employer has an obligation to provide a regular retirement check to employees upon their retirement.

Typically, a DB teacher pension plan requires that both teachers and employers make a contribution each year to a pension trust fund. On average, these contributions are smaller for those teachers who are part of the Social Security system and larger for those who are not covered. We estimate that in the systems covered by Social Security, employees contribute an average of 4.5 percent and employers contribute 9.0 percent, for a total of 13.5 percent. This is in addition to the 12.4 percent combined employer and employee contribution to the Social Security system. By contrast, in noncovered systems, employees contribute an average of 7.8 percent and employers contribute 11.1 percent, for a total of 18.9 percent (Costrell and Podgursky 2009).

In a fully funded system, these contributions and the investment returns they earn should cover the benefits these teachers are accruing for their future retirement. However, in many states the teacher pension systems have accrued large unfunded liabilities.[6] These have arisen for several reasons; most systems were originally pay as you go (i.e., no pre-funding), and benefits have been added over time (including early retirement benefits) without commensurate funding. As a result, employer and teacher contributions must cover not only the currently accruing liabilities (known as normal costs) but also the amortization of previously accrued unfunded liabilities—the so-called legacy costs.[7]

5. Data collected by the U.S. Department of Labor show that DC plans now predominate in the private sector (Hansen 2008).
6. The unfunded liabilities and funding ratios for pension funds in the six states included in this study, as of 2007, are: Arkansas ($1.8 billion, 85.3 percent), California ($19.6 billion, 87.0 percent [2006]), Massachusetts ($9.7 billion, 69.3 percent [including Boston]), Missouri ($5.3 billion, 83.5 percent), Ohio ($14.5 billion, 82.2 percent), and Texas ($12.5 billion, 89.2 percent). Sources: Public Employee Retirement Administration Commission (PERAC) 2007; Public School and Education Employee Retirement Systems of Missouri (PSRS/PEERS) 2007; State Teachers Retirement System of Ohio (STRSOH) 2007a; Teacher Retirement System of Texas (TRS) 2007a; Arkansas Teacher Retirement System (ATRS) 2008; California State Teachers' Retirement System (CalSTRS) 2008. Note that all these estimates discount future liabilities at rates of 8 percent or higher. Most financial economists believe that these future liabilities should be discounted at a lower (and low risk) rate, which is required accounting practice for private sector pension funds. Were that practice followed for these public teacher funds, the funding ratios would be much lower (Waring 2008).
7. It is important to note that these contributions do not include future costs for retiree health insurance—an issue that is now beginning to appear on education finance radar screens.

Once a teacher is vested (usually after five or ten years), she or he becomes eligible to receive a pension upon reaching a certain age and/or length of service. Different versions of these eligibility rules are discussed below, but they typically allow teachers to draw a pension well before age 65, especially if they have been working since their mid-20s.

Benefits at retirement are usually determined by a formula of the following sort:

$$\textit{Annual Benefit} = r(YOS, Age) \cdot YOS \cdot FAS. \qquad (1)$$

In this expression, YOS denotes years of service, the final average salary (FAS) is an average of the last few years of salary (typically three), and r is a percentage that we will call the "replacement factor" that may be constant but is often a function of service and age.[8] In Missouri, for example, teachers at normal retirement earn 2.5 percent for each year of teaching service. Thus a teacher with thirty years of service would earn 75 percent of the final average salary. So if the final average salary were $60,000 the teacher would receive:

$$\textit{Annual Benefit} = .025 \times 30 \times \$60{,}000 = \$45{,}000,$$

payable for life. If the teacher were to separate from service prior to being eligible to receive the pension, the first draw would be deferred and the amount of the pension would be frozen until that time. Once the pension draw begins, there is typically some form of inflation adjustment, although the nature of it varies from state to state.

Table 1 summarizes some of the key parameters of DB pension plans in six states. While not randomly chosen (we inhabit two of these states), they are broadly representative of the universe of teacher pension plans.[9] More complete tables have been published by the National Education Association (NEA) and others, showing similar variation in these pension parameters across states (NEA 2006; Loeb and Miller 2006).

The complexity of the formula varies from state to state. Arkansas, for example, has a relatively simple formula. Once one reaches age sixty or twenty-eight years of service, one can draw a pension equal to the final average salary times 2.15 percent times years of service (plus $900 per year). One can start drawing the pension earlier, after twenty-five, twenty-six, or twenty-seven years of service, but with an adjustment of 85 percent, 90 percent, or 95 percent,

8. States will often specify a replacement factor for "normal" retirement but also have various "early" retirement provisions that can be expressed as age- or service-based reductions in the normal replacement factor.
9. These six states account for 29 percent of the total fall 2004 employment of public school teachers (U.S. Department of Education 2008, table 63).

Table 1. Key Features of Selected State Defined Benefit Teacher Pension Plans

	Ohio	Arkansas	California	Massachusetts	Missouri	Texas
In Social Security	No	Yes	No	No	No	Varies by district
Vesting (years)	5	5	5	10	5	5
Retirement eligibility (normal or early)	Normal: Age = 65; or YOS = 30 Early: Age = 60; or age = 55 if YOS = 25	Normal: Age = 60; or YOS = 28 Early: YOS = 25	Age = 55; or age = 50 if YOS = 30	Age = 55; or YOS = 20	Normal: Age = 60; or YOS = 30; or age + YOS = 80 Early: Age = 55; or YOS = 25	Normal: Age = 65; or age + YOS = 80 and age = 60 Early: Age = 55; or YOS = 30; or age + YOS = 80
Contribution rates	District 14%[a] Teacher 10%	Employer 14% Teacher 6%[b]	Employer 8.25% State 4.52%[c] Teacher 8%[d]	State 15.6%[e] Teacher 11%[f]	District 12.5% Teacher 12.5%	State 7.98%[g] Teacher 6.9%[h]
Replacement factor (percent per year of service)	Years 1–30: 2.2% Year 31 only: 2.5% Year 32 only: 2.6%, . . . For YOS ≥ 35, add 9% to total	2.15% + $900	Linear segments: 1.1% at age 50 1.4% at age 55 2.0% at age 60 2.4% at age 63 For YOS ≥ 30, add 0.2% to factor, to max of 2.4%	Linear: 0.1% at age 41 to 2.5% at age 65 For YOS ≥ 30, add 2% × (YOS – 24) Max replacement = 80%	Normal, or age = 55: 2.5%, YOS ≤ 30, 2.55%, YOS > 30 Early: 25 ≤ YOS < 30: 2.20%, YOS = 25 rising linearly to 2.40%, YOS = 29	2.3%
COLA formula	3%, simple	3%, simple	2%, simple, plus floor of 80% initial purchasing power	3%, simple, on first $12,000	CPI, compound, up to 1.80 maximum factor	None in statute (periodic, retroactive)

Notes: YOS = years of service; COLA = cost of living allowance; CPI = consumer price index.
[a]Includes 1% for retiree health insurance.
[b]Contributory members only. Average is 4.80%, including noncontributory.
[c]Includes 2.5% for 80% floor on initial purchasing power (see CalSTRS 2007, p. 7).
[d]Includes 2% for a supplemental defined contribution plan (see CalSTRS 2007, p. 11).
[e]Calculated from FY07 state appropriation (PERAC 2007).
[f]For all teachers hired since 2000.
[g]Includes 1.4% for retiree health insurance.
[h]Includes 0.5% for retiree health insurance.
Sources: NASRA (2008); individual state comprehensive annual financial reports and pension handbooks (MTRS 2006; ATRS 2007; CalSTRS 2007; PSRS 2008; STRS Ohio 2007b; TRS 2007b).

respectively. The formulas of other states are more complicated, as we shall see below.

The composite effect of these systems—whether they are simple or complex—is hard to discern from the system's parameters. To appreciate the powerful incentive effects of these systems, and thus make informative comparisons among states, we use the parameters to examine how teachers accumulate pension wealth with each year of employment.

3. PENSION WEALTH AND EARNINGS WEALTH

The parameters of teacher pension plans can be used to estimate the magnitude of pension benefits using the concept of present value. When an individual retires under a DB plan, he or she is entitled to a stream of payments with a lump sum value that can be readily determined using standard actuarial methods. By the same token, the stream of earnings over one's work life can also be converted to a lump sum for the purpose of comparison. It is simply the cumulative earnings over time, with interest accrued. Hence the two streams of income—earnings during one's work life and pension benefits during retirement—can be placed on a common footing.

Formally, consider an individual's pension wealth, P, at some potential age of separation, A_s. The stream of expected payments may begin immediately or may (perhaps must) be deferred until some later retirement age. The present value of those payments is:

$$P(A_s) = \sum_{A \geq A_s} (1 + r)^{(A_s - A)} f(A \mid A_s) \cdot B(A \mid A_s), \tag{2}$$

where $B(A \mid A_s)$ is the defined benefit one will receive at age A, given that one has separated at age A_s, and $f(A \mid A_s)$ is the conditional probability of survival to that age.

The benefit stream may itself be a choice among alternative streams open to the individual, based upon the choice of when to begin receiving payments. The best choice is often simply to receive benefits as soon after separation as possible—but not always, since there may be an age reduction in benefits for receipt prior to "normal" retirement age. In modeling pension wealth below, we assume that individuals separating at age A_s will choose the stream of payments that maximizes present value.[10]

10. This is not as strong an assumption as it might appear at first sight. We are *not* assuming that teachers choose their age of separation to maximize present value—that is the major decision, and obviously there are many other factors that affect it. We are *only* assuming here that for any given age of separation, where the individual has to choose whether to collect the pension immediately (if eligible) or to defer, and for how long, *this* decision (a relatively minor one) is based on maximizing present value. In cases in which it pays to defer, teachers may well receive advice to that effect from the pension professionals in the state retirement office. In many cases the formula is such that

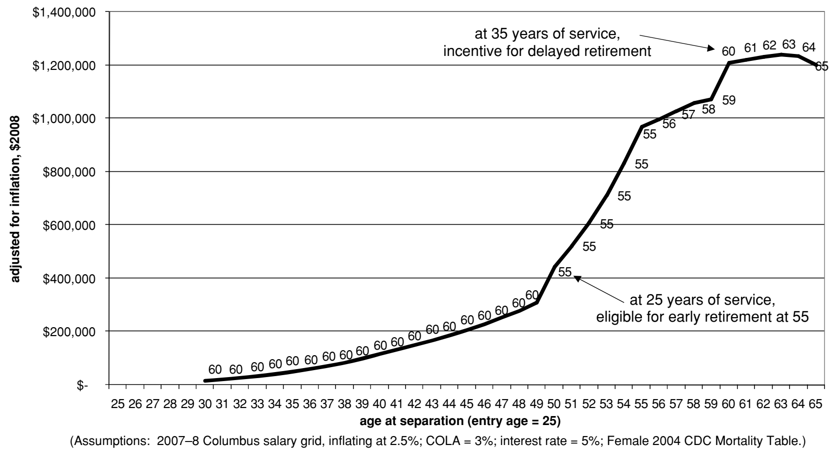

Figure 1. Pension Wealth, in Dollars: Ohio (age of first pension draw indicated)

In principle, $P(A_s)$ represents the market value of the annuity. If instead of providing a promise to pay annual benefits the employer provides a lump sum of this magnitude upon separation, the employee could buy the same annuity on the market. The teacher's pension wealth, $P(A_s)$, is the size of the 401(k) that would be required to generate the same stream of payments he or she would be owed upon separation at age A_s.

Figure 1 depicts the pension wealth, in inflation-adjusted dollars, for a twenty-five-year-old entrant to the Ohio teaching force who works continuously until leaving service at various ages of separation.[11] The salary schedule assumed is that of the state capital (Columbus), under which teachers receive annual step increases and also lane increases as they move from a B.A. to a master's degree. The entire salary grid is assumed to increase at 2.5 percent inflation.[12] We assume a 5 percent interest rate[13] and use the most current

discretionary deferrals are actuarially similar to one another, so the precise choice made is not that important. For all these reasons, the assumption made in the text is not particularly strong.

11. Similar diagrams can be drawn for individuals entering service at different ages.
12. Typically a three-year contract will include three grids, each of which is an increase over the preceding one, and subsequent contracts will have grids that are similarly higher. So, for example, if a teacher's first step increase is 4 percent, she will receive that increase plus the effect of moving to the next year's grid, assumed here to be 2.5 percent higher, for a total increase of 6.6 percent ($1.04 \times 1.025 - 1$). If the teacher also shifts "lanes" by acquiring a master's degree (assumed here to occur after six years), there is an additional increase. Most grids have a top step (14 in Columbus), after which the only increases are due to shifts in the grid, except for longevity increases that may also be included, for example, at years 19, 23, 27, and 30 in Columbus's contract.
13. As mentioned in note 6, there is a dispute between financial economists and actuaries regarding the prudent assumption for the rate of return. The 5 percent figure here is closer to the economists' recommendation than that of the actuaries, who typically use about 8 percent. The higher discount rate will affect the dollar amount for figure 1 (e.g., the pension wealth for a teacher separating at age fifty-six drops from $997,000 to $724,000) but will not have much effect on the spikes and valleys in the other diagrams, which are the main focus of this article.

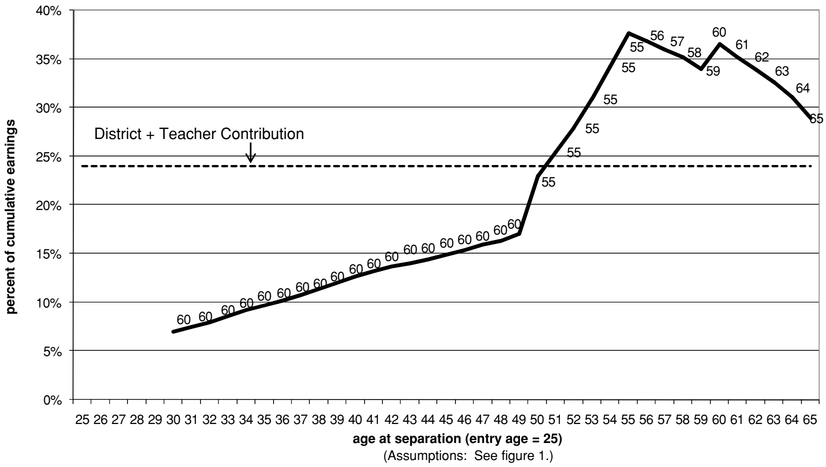

Figure 2. Pension Wealth as Percent of Cumulative Earnings: Ohio (age of first pension draw indicated)

female mortality tables (Arias 2007) from the Centers for Disease Control and Prevention (CDC).[14]

The accumulation of pension wealth is not smooth and steady, but rises with fits and starts after age forty-nine, due to eligibility rules for early retirement and the like (discussed in more detail below). During her first twenty-four years in the classroom, this teacher accumulates about $309,000 in pension wealth. However, over the next six years she accumulates more than $100,000 per year, approaching the million dollar mark by age fifty-five. Pension wealth reaches a peak by her early sixties and then starts to decline.

For purposes of comparison, it is useful to define one's earnings wealth analogously to that of pension wealth:

$$E(A_s) = \sum_{A<A_s} (1+r)^{(A_s - A - 1)} W(A), \tag{3}$$

where $W(A)$ is one's annual wage at age A. Thus $E(A_s)$ is simply cumulative earnings with accrued interest. It can be thought of as the lump sum that would have been sufficient to fund the stream of earnings, as evaluated at the age of separation. Since pension wealth is the present value of a stream of payments going forward and earnings wealth is the present value of a stream of payments going backward, both evaluated at the same point in time (at age A_s), they are comparable measures, capitalizing these two components of compensation.

Figure 2 depicts pension wealth as a percentage of cumulative earnings, $P(A_s)/E(A_s)$. This measure has a fairly intuitive interpretation. If one nets

14. Most teachers are female. For males, the pension wealth is a bit lower due to shorter life expectancies, but the curves have very similar shapes.

out the employee contribution (10 percent in the case of Ohio), it expresses deferred compensation as a percent add-on to compensation during one's working life. Thus an individual separating at age fifty-five receives pension benefits worth 38 percent of cumulative earnings, for a net fringe benefit rate of 28 percent. Conversely, an individual separating at age thirty would receive pension benefits worth only 7 percent of cumulative earnings, which is negative, net of employee contribution, so this individual (and others up to age thirty-five) would be better off withdrawing her contributions even though she is vested.

The pension wealth measure $P(A_s)/E(A_s)$ also has a more concrete interpretation from the funding side. It represents the percentage of earnings that must be set aside each year (from employer and/or employee) in order to fully fund the pension benefits, for any given age of separation.[15] Clearly, those individuals who retire in their mid- to late fifties receive significantly more in benefits than has been contributed to the system on their behalf, while those who separate from service earlier in their career do not. Figure 2 therefore illustrates the uneven distribution of benefits that is built into the system. Subtracting out the Ohio teachers' contribution of 10 percent of earnings, one sees that the net benefits are even more unequally distributed than the gross benefits.

This is true of other states as well. Comparable diagrams typically show a single peak in pension wealth, as a percent of cumulative earnings, but there is significant variation due to the specifics of each state's benefit formula (see Costrell and Podgursky 2007a for these other diagrams).

Finally, note that a state's pension wealth curve often has distinct segments, with markedly different slopes, as in figure 1. The important implication of this is that the annual increments to pension wealth at different ages can vary quite dramatically, as we shall presently show.

4. ANNUAL CHANGE IN PENSION WEALTH AS A MEASURE OF DEFERRED COMPENSATION

The evolution of a teacher's pension wealth over her career captures the incentives embedded in the pension system. Properly calculated, the change in pension wealth is a measure of deferred compensation, which can be compared with current compensation. Specifically, one must distinguish between changes in wealth due to a change in the stream of payments (evaluated at the same point in time) and a change in wealth due solely to the passage of time. The latter piece is simply the interest on the previous year's wealth—it is the return to capital, not labor. It is the former piece, the change in wealth due to a

15. This does not include the portion of contributions to amortize unfunded liabilities from previous cohorts.

change in the stream of payments, that is the proper measure of labor income. Finally, we must also net out the employee's contribution to the pension fund because that cannot be considered part of labor income.

Recall that pension wealth is the size of the 401(k) that would be required to purchase the stream of pension benefits. Thus the growth of that notional 401(k), net of interest and net of employee contributions, is conceptually identical to the 401(k) contributions made by the employer. That is, our measure of deferred income is equivalent to the employer's annual contribution to the corresponding 401(k) plan.

Formally, the change in pension wealth net of interest is:[16]

$$p(A_s) \equiv \Delta P(A_s) - r \cdot P(A_s - 1). \tag{4}$$

This can be expressed more explicitly as:

$$p(A_s) = \sum_{A \geq A_s} (1+r)^{(A_s - A)} [f(A \mid A_s) B(A \mid A_s) - f(A \mid A_s - 1) B(A \mid A_s - 1)] - (1+r)\, B(A_s - 1 \mid A_s - 1)\,. \tag{5}$$

As stated earlier, this is the effect on wealth of deferring separation due to changes in the expected stream of pension payments.

Let us examine equation 5 in more detail. The first term represents the increase in expected pension payments from A_s forward. We see from the bracketed expression, which is positive, that this is due to the rise in benefits from the pension formula ($B(A \mid A_s) > B(A \mid A_s - 1)$), as well as the higher probability of surviving to receive each benefit payment ($f(A \mid A_s) > f(A \mid A_s - 1)$).

Note that if A_s is at an age or service level where the formula allows one to accelerate the first pension draw (e.g., age fifty in Ohio, as shown in figure 1 and discussed further below), then one or more of the $B(A \mid A_s - 1)$ terms are zero while the corresponding $B(A \mid A_s)$ terms are positive. Thus at such an age the annual income from deferred compensation includes the sudden addition of one or more years of pension payments, frontloaded. Conversely, if one were already eligible to receive a pension the previous year, at age $A_s - 1$, then deferring separation forgoes that benefit payment, as shown in the last term in equation 5.

In sum, the income from deferred compensation in any given year has several conceptual pieces: (1) the rise in expected benefit payments due to the formula (more years of service, higher final average salary, and, in some states, a higher replacement factor); (2) at certain break points in the formula,

16. Analogously, it can be easily shown that the change in earnings wealth, net of interest on the prior year's earnings wealth, is simply the annual earnings income: $e(A_s) \equiv \Delta E(A_s) - r \cdot E(A_s - 1) = W(A_s - 1)$.

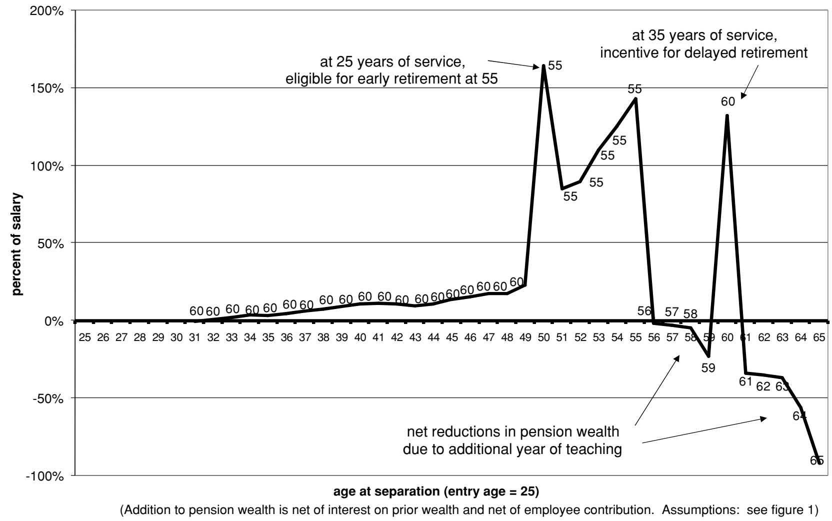

Figure 3. Deferred Income per Year, as Percent of Salary: Ohio. Net Addition to Pension Wealth from an Additional Year of Teaching (age of first pension draw indicated)

additional years of pension eligibility; and (3) later in one's career, the loss of a year of benefits from deferring separation.

5. PENSION SPIKES

Figures 3–9 are the most important for an analysis of labor market behavior. Here we show the change in net pension wealth arising from an additional year of work, expressed as a percent of salary for Ohio and five other states. Behind each of these charts is a pension wealth accrual chart such as that in figure 1. Each of these charts answers the question posed above: how much does a teacher's net pension wealth change if she or he works an additional year? Specifically, we consider *deferred* income (net of interest on prior pension wealth and net of employee contributions), expressed as a percent of the teacher's salary.[17]

Ohio

Consider Ohio, depicted in figure 3. A teacher who enters service at age twenty-five accrues pension wealth upon vesting (five years), starting at roughly

17. It is important to note that the pension accrual concept used here is different from the actuarial concept. The actuarial concept is based on the assumption that the individual will work to a given normal retirement age, independent of the age at which the accrual is being evaluated. It is calculated to guide the employer in providing prudent reserves, and it results in smooth curves. The economist's concept, depicted here, considers each year as the individual's year of separation; it is calculated to depict the incentives for individual decisions about separation. As has been previously established in the economics literature (e.g., Kotlikoff and Wise 1987; Friedberg and Webb 2005), these curves have sharp kinks, leading to strong incentives to stay or leave at various ages.

10 percent of annual earnings. This is offset by her contribution to the fund, so her net addition to wealth is zero. This is her deferred income that year. Her deferred income gradually rises to 23 percent of her salary in her twenty-fourth year (age forty-nine). Throughout this period, her deferred income reflects the credit she is accruing to a higher pension, collectable at age sixty.

After her twenty-fifth year (age fifty), the eligibility rules allow her to collect benefits starting five years early, deferring the first pension draw to age fifty-five instead of sixty. This yields a large sudden increase in pension wealth. In that year her net pension wealth jumps by 164 percent of her annual earnings. Each of the next five years also yields deferred income that approaches or exceeds her current income. Here the reason is not additional years of pension eligibility. Rather, annual deferred income is high because the early retirement reduction gets phased out over this period, rapidly raising the annual pension, until thirty years of service, when she qualifies for "normal" retirement.

The growth of pension wealth drops off sharply over the next few years—it actually goes negative for ages 56–59. Her annual pension continues to rise with each additional year of service (albeit more slowly). But this is entirely offset by the fact that she has now reached the point where she collects her pension immediately upon separation, so each additional year of work means forgoing a year of pension payments.

This is followed by yet another sharp spike at age sixty (thirty-five years experience), equal to 132 percent of her salary that year. That is because Ohio has an incentive for delayed retirement, adding 9 percent to the total replacement rate after thirty-five years (as indicated in table 1), beyond the 2.9 percent given by the formula.

Beyond age sixty, pension wealth shrinks once again (net of interest) and at an accelerating rate. At age sixty-one, her pension contribution and reduction in pension wealth constitute an implicit 33 percent tax on her earnings (over and above her state and federal income tax). By age sixty-five, the pension system is imposing a tax of 92 percent, so, together with her income tax, she is effectively paying for the privilege of teaching.

Table 2 gives more detail on what is going on in figure 3. Each cell gives the starting annual pension, as a percent of FAS for the corresponding YOS and age. The blank region indicates no pension eligibility. The region with bold figures (age $= 65$ or YOS ≥ 30) is the region of normal retirement, and the bonus year YOS $= 35$ is indicated by bold italic figures. The region with unbolded italic figures is the region of early retirement, where the pension is reduced by various adjustment factors. The table's shaded cells denote the wealth-maximizing choice of first pension draw for a twenty-five-year-old entrant, after separation at any given YOS.

Table 2. Starting Annuity, as Percent of Final Average Salary, Ohio

YOS/Age	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65
5																9.4	9.7	10.0	10.3	10.7	11.0
6																11.2	11.6	12.0	12.4	12.8	13.2
7																13.1	13.6	14.0	14.5	14.9	15.4
8																15.0	15.5	16.0	16.5	17.1	17.6
9																16.8	17.4	18.0	18.6	19.2	19.8
10																18.7	19.4	20.0	20.7	21.3	22.0
11																20.6	21.3	22.0	22.7	23.5	24.2
12																22.4	23.2	24.0	24.8	25.6	26.4
13																24.3	25.2	26.0	26.9	27.7	28.6
14																26.2	27.1	28.0	29.0	29.9	30.8
15																28.1	29.0	30.0	31.0	32.0	33.0
16																29.9	31.0	32.0	33.1	34.1	35.2
17																31.8	32.9	34.0	35.2	36.3	37.4
18																33.7	34.8	36.0	37.2	38.4	39.6
19																35.5	36.8	38.0	39.3	40.5	41.8
20																37.4	38.7	40.0	41.4	42.7	44.0
21																39.3	40.7	42.0	43.4	44.8	46.2
22																41.1	42.6	44.0	45.5	46.9	48.4
23																43.0	44.5	46.0	47.6	49.1	50.6
24																44.9	46.5	48.0	49.6	51.2	52.8
25											41.3	41.3	41.3	41.3	44.0	46.8	48.4	50.1	51.7	53.4	55.0
26											45.8	45.8	45.8	45.8	45.8	48.6	50.3	52.1	53.8	55.5	57.2
27											50.5	50.5	50.5	50.5	50.5	50.5	52.3	54.1	55.8	57.6	59.4
28											55.4	55.4	55.4	55.4	55.4	55.4	55.4	56.1	57.9	59.8	61.6
29											60.6	60.6	60.6	60.6	60.6	60.6	60.6	60.6	60.6	61.9	63.8
30	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0
31	68.5	68.5	68.5	68.5	68.5	68.5	68.5	68.5	68.5	68.5	68.5	68.5	68.5	68.5	68.5	68.5	68.5	68.5	68.5	68.5	68.5
32	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1
33	73.8	73.8	73.8	73.8	73.8	73.8	73.8	73.8	73.8	73.8	73.8	73.8	73.8	73.8	73.8	73.8	73.8	73.8	73.8	73.8	73.8
34	76.6	76.6	76.6	76.6	76.6	76.6	76.6	76.6	76.6	76.6	76.6	76.6	76.6	76.6	76.6	76.6	76.6	76.6	76.6	76.6	76.6
35	88.5	88.5	88.5	88.5	88.5	88.5	88.5	88.5	88.5	88.5	88.5	88.5	88.5	88.5	88.5	88.5	88.5	88.5	88.5	88.5	88.5
36	91.5	91.5	91.5	91.5	91.5	91.5	91.5	91.5	91.5	91.5	91.5	91.5	91.5	91.5	91.5	91.5	91.5	91.5	91.5	91.5	91.5
37	94.6	94.6	94.6	94.6	94.6	94.6	94.6	94.6	94.6	94.6	94.6	94.6	94.6	94.6	94.6	94.6	94.6	94.6	94.6	94.6	94.6
38	97.8	97.8	97.8	97.8	97.8	97.8	97.8	97.8	97.8	97.8	97.8	97.8	97.8	97.8	97.8	97.8	97.8	97.8	97.8	97.8	97.8
39	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
40	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Notes: Italics = early retirement; bold = normal retirement; bold italics = 35-year bonus. Shaded cells = first draw of 25-year-old female entrant.

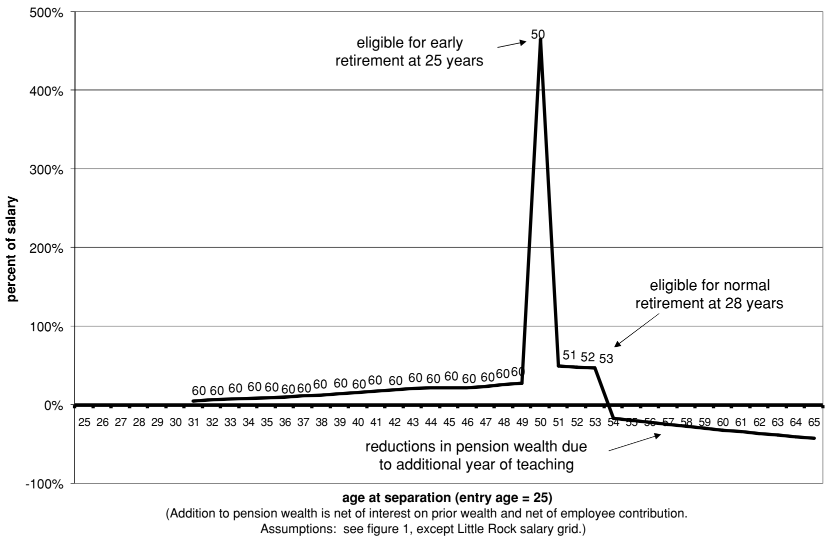

Figure 4. Deferred Income per Year, as Percent of Salary: Arkansas. Net Addition to Pension Wealth from an Additional Year of Teaching (age of first pension draw indicated)

As the table shows, age sixty is the earliest she can collect up through her twenty-fourth year of service, and that does in fact maximize pension wealth, even though further deferral (e.g., to the "normal" retirement age of 65) would raise her annual pension. Upon her twenty-fifth year, she maximizes pension wealth by taking the five extra years of pension eligibility (jumping from the shaded cell at [24, 60] to the one at [25, 55]), despite the fact that the pension is reduced from 44.9 percent of FAS to 41.3 percent. The draw at age fifty-five continues to be her optimal choice until she reaches age fifty-five, at thirty years of service. For service beyond that point, her first draw is immediate upon separation, so the shaded cells move diagonally to the southeast. Note the particularly large jump in the annual pension, from 76.6 percent of FAS to 88.5 percent, at YOS = 35, the bonus that generates figure 3's third spike.

Arkansas

The case of Ohio is a bit more convoluted than most—its system of incentives for early retirement and for delayed retirement results in multiple spikes. But most of the state systems we have examined also display sharp pension spikes. In Arkansas, a particularly sharp spike occurs at age fifty (twenty-fifth year of service for a twenty-five-year-old entrant), as depicted in figure 4. In that year, our teacher would earn an increase in pension wealth worth almost five times her salary. In other words, a teacher with a $50,000 salary would earn total compensation of nearly $300,000 for that year of teaching, before dropping off precipitously the next year. The reason is that she is eligible for ten extra years of pension payments because she qualifies for early retirement immediately after 25 YOS, instead of having to defer to age sixty. Upon reaching 28 YOS, she qualifies for normal retirement, and beyond that point—age fifty-three for a twenty-five-year-old entrant—her deferred income turns negative each year. This is because the rise in annual pension does not outweigh the loss of a year's pension payment.

Missouri

Missouri's formula is a bit more complicated. It allows one to draw a normal pension at age ≥ 60 or YOS ≥ 30 but also has a "rule of 80" under which one is eligible once age + YOS reaches 80. In table 3, normal retirement is represented by the region with bold figures, and the rule of 80 is represented by the serrated border of that region. Alternatively, one can take early retirement at ages 55–59 with downward adjustment factors, or with YOS from 25 to 29 ("25 and out") but with lower replacement factors (2.20%–2.40% instead of the normal 2.50%).[18] These options are represented by the two wedge-shaped regions in table 3 with italicized figures.

This formula, like that in Ohio, gives rise to multiple spikes, depicted in figure 5. A twenty-five-year-old entrant considering separation during her first twenty years would do best to defer her first pension draw to normal retirement at age sixty. Her twenty-first year of service (at age forty-six) allows her to bring the first pension draw forward a year, to age fifty-nine, under the rule of 80. She then starts moving down the serrated border of the normal retirement region in table 3. This extra year of pension eligibility gives a bump to her pension wealth accrual that year, seen in figure 5. This recurs for each of the next three years. If she were to stay on through her twenty-fifth year (age fifty), she qualifies for the attractive 25-and-out option, under which she would collect immediately. This means six extra years of pension eligibility, as she jumps from the shaded cell [24, 56] in table 3 to [25, 50]. This generates her biggest pension spike in figure 5, worth almost four times her salary. If she stays two more years, she should avail herself again of the rule of 80, and at age fifty-three (28 YOS) she would qualify for normal retirement immediately upon separation—her second spike. A third bump occurs at age 56 due to an increase in the replacement factor at 31 YOS. Beyond that point, deferred income turns negative.

18. This 25-and-out provision has been a "temporary" feature of Missouri code since 1996. Originally set to expire in 1998, it was enhanced and extended to 2000 and then again to 2003, 2008, and 2013.

Table 3. Starting Annuity, as Percent of Final Average Salary, Missouri

YOS/Age	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65
5											7.9	8.6	9.5	10.4	11.4	12.5	12.5	12.5	12.5	12.5	12.5
6											9.5	10.4	11.3	12.4	13.7	15.0	15.0	15.0	15.0	15.0	15.0
7											11.1	12.1	13.2	14.5	15.9	17.5	17.5	17.5	17.5	17.5	17.5
8											12.6	13.8	15.1	16.6	18.2	20.0	20.0	20.0	20.0	20.0	20.0
9											14.2	15.5	17.0	18.7	20.5	22.5	22.5	22.5	22.5	22.5	22.5
10											15.8	17.3	18.9	20.7	22.8	25.0	25.0	25.0	25.0	25.0	25.0
11											17.4	19.0	20.8	22.8	25.0	27.5	27.5	27.5	27.5	27.5	27.5
12											18.9	20.7	22.7	24.9	27.3	30.0	30.0	30.0	30.0	30.0	30.0
13											20.5	22.5	24.6	27.0	29.6	32.5	32.5	32.5	32.5	32.5	32.5
14											22.1	24.2	26.5	29.0	31.9	35.0	35.0	35.0	35.0	35.0	35.0
15											23.7	25.9	28.4	31.1	34.1	37.5	37.5	37.5	37.5	37.5	37.5
16											25.3	27.6	30.3	33.2	36.4	40.0	40.0	40.0	40.0	40.0	40.0
17											26.8	29.4	32.2	35.2	38.7	42.5	42.5	42.5	42.5	42.5	42.5
18											28.4	31.1	34.0	37.3	41.0	45.0	45.0	45.0	45.0	45.0	45.0
19											30.0	32.8	35.9	39.4	43.2	47.5	47.5	47.5	47.5	47.5	47.5
20											31.6	34.5	37.8	41.5	45.5	50.0	50.0	50.0	50.0	50.0	50.0
21											33.2	36.3	39.7	43.5	52.5	52.5	52.5	52.5	52.5	52.5	52.5
22											34.7	38.0	41.6	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0
23											36.3	39.7	57.5	57.5	57.5	57.5	57.5	57.5	57.5	57.5	57.5
24											37.9	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
25	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5
26	58.5	58.5	58.5	58.5	58.5	58.5	58.5	58.5	58.5	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0
27	62.1	62.1	62.1	62.1	62.1	62.1	62.1	62.1	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5
28	65.8	65.8	65.8	65.8	65.8	65.8	65.8	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
29	69.6	69.6	69.6	69.6	69.6	69.6	72.5	72.5	72.5	72.5	72.5	72.5	72.5	72.5	72.5	72.5	72.5	72.5	72.5	72.5	72.5
30	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0
31	79.1	79.1	79.1	79.1	79.1	79.1	79.1	79.1	79.1	79.1	79.1	79.1	79.1	79.1	79.1	79.1	79.1	79.1	79.1	79.1	79.1
32	81.6	81.6	81.6	81.6	81.6	81.6	81.6	81.6	81.6	81.6	81.6	81.6	81.6	81.6	81.6	81.6	81.6	81.6	81.6	81.6	81.6
33	84.2	84.2	84.2	84.2	84.2	84.2	84.2	84.2	84.2	84.2	84.2	84.2	84.2	84.2	84.2	84.2	84.2	84.2	84.2	84.2	84.2
34	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7
35	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3
36	91.8	91.8	91.8	91.8	91.8	91.8	91.8	91.8	91.8	91.8	91.8	91.8	91.8	91.8	91.8	91.8	91.8	91.8	91.8	91.8	91.8
37	94.4	94.4	94.4	94.4	94.4	94.4	94.4	94.4	94.4	94.4	94.4	94.4	94.4	94.4	94.4	94.4	94.4	94.4	94.4	94.4	94.4
38	96.9	96.9	96.9	96.9	96.9	96.9	96.9	96.9	96.9	96.9	96.9	96.9	96.9	96.9	96.9	96.9	96.9	96.9	96.9	96.9	96.9
39	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5
40	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Notes: Italics = early retirement; bold = normal retirement; bold italics = 31-year bonus. Shaded cells = first draw of 25-year-old female entrant.

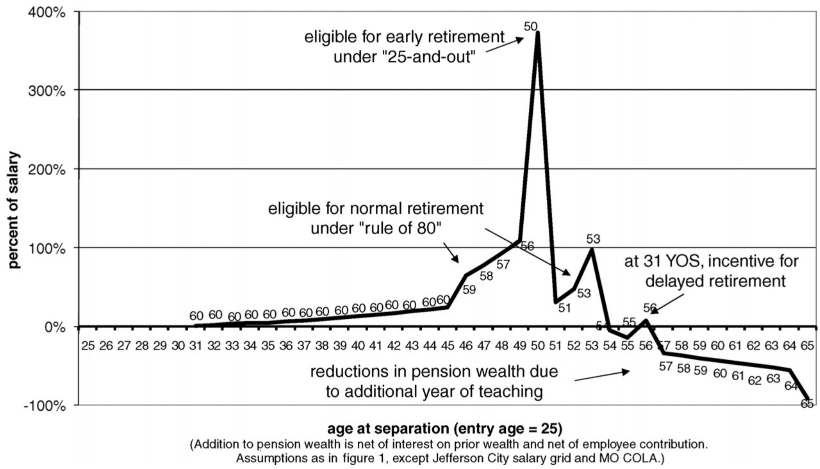

Figure 5. Deferred Income per Year, as Percent of Salary: Missouri. Net Addition to Pension Wealth from an Additional Year of Teaching (age of first pension draw indicated)

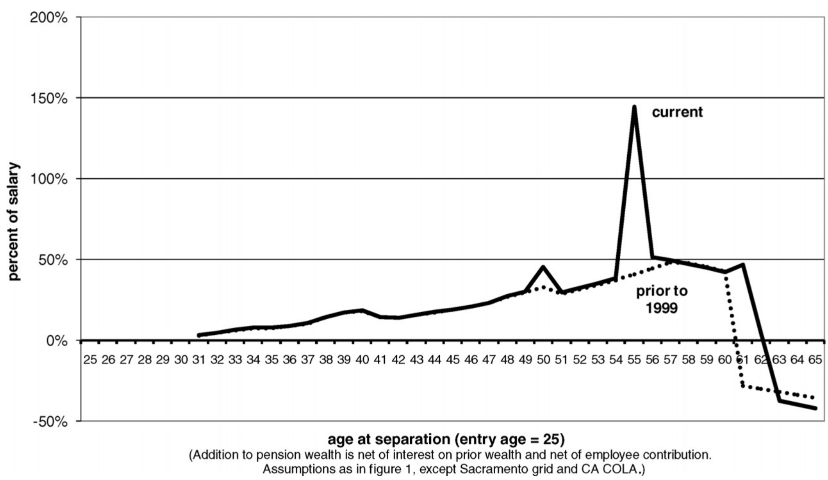

Figure 6. Deferred Income per Year, as Percent of Salary: California. Net Addition to Pension Wealth from an Additional Year of Teaching

Other States and General Comments

The pension systems in California and Massachusetts also generate spikes for our representative teacher in her early to mid-fifties (figures 6–7), as did the system in Texas, prior to recent changes (figure 8). The details of what generates each spike vary from state to state, but there are a few general points.

Since both the teacher and the employer are making the same contributions year after year, one might imagine that pension wealth accrual would be fairly smooth and consistent. However, contribution rates do not drive wealth accrual in these pension plans. Pension wealth is only loosely tied to contributions. The

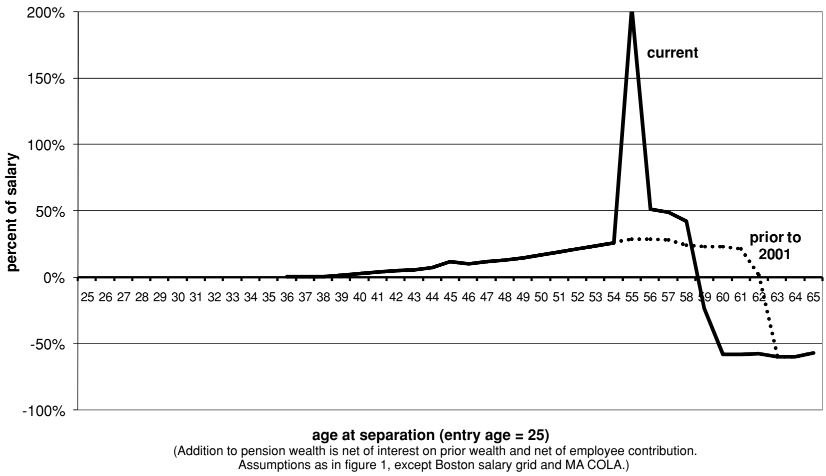

Figure 7. Deferred Income per Year, as Percent of Salary: Massachusetts. Net Addition to Pension Wealth from an Additional Year of Teaching

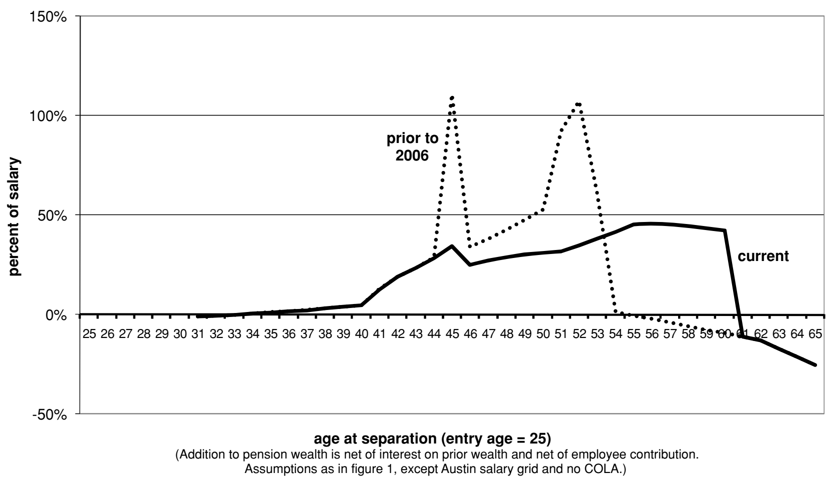

Figure 8. Deferred Income per Year, as Percent of Salary: Texas. Net Addition to Pension Wealth from an Additional Year of Teaching

primary drivers in pension wealth accrual are changes in the annual annuity payment (determined by equation 1) and the number of years the teacher can expect to collect it. As we have seen, it is the latter that is often the wild card in these systems. In other cases, spikes are created by enhancements to the benefit formula at specified ages or YOS.

As mentioned above, pension accrual spikes have been documented by previous researchers in other sectors, notably by Kotlikoff and Wise (1987) in their exhaustive analysis of thousands of private sector plans. However, the magnitude of the spikes we have found in teacher systems dwarfs those found by Kotlikoff and Wise, typically by an order of magnitude.[19] One important reason for this appears to be a difference in early retirement provisions between many teacher systems today and the private DB systems of the 1980s. Those private systems tended to reduce early retirement pensions based on age rather than service; the reductions were often less than actuarially warranted—hence the spikes—but age was at least the actuarially relevant variable. By contrast, teacher systems often condition early retirement on YOS thresholds, which are unrelated to the present value of future benefits.[20] This accentuates the disjunction between benefits and contributions, playing a significant role in generating the very large spikes we have seen.

Once teachers get past the spike (or spikes), pension wealth accrual turns negative. For all these states this occurs by the early sixties, and in some states it occurs much earlier. This is not because the annual pension annuity falls. In fact, it is rising (although eventually teachers hit a pension cap typically set at 100 percent of earnings). Instead pension wealth falls because the teacher collects the pension for one less year and the annual payment is not enhanced sufficiently to offset this loss.

Finally, these charts also illustrate how legislatures alter these incentive structures periodically (even if the public policy impact may not always have been fully understood at the time). In the cases of California and Massachusetts (see figures 6 and 7), these spikes were created by benefit enhancements enacted when pension funds were flush, following the bull market of the 1990s.[21] Ohio's multiple-spiked system also reflects benefit enhancements enacted over

19. For example, among the 513 plans that set early retirement at age fifty-five and normal retirement at age sixty-five, the median accrual rate at age fifty-five (where the main spike generally occurs for these plans) was found to be 10 percent. That accrual rate was 21 percent for the plan at the largest fifth percentile by average accrual and 41 percent for the plan with the maximum accrual ratios (Kotlikoff and Wise 1987, table 10.3).
20. YOS is related to contributions, and this is crudely represented in the basic benefit formula, $r \cdot YOS \cdot FAS$, but the YOS-eligibility rules for teachers lead to large discontinuities, as we have seen. The calculations in Kotlikoff and Wise ignore service requirements for early retirement, but the minimal nature of those requirements leads them to conclude that this is unlikely to significantly affect their results (see their note 2).
21. Prior to these changes, California and Massachusetts did not have notable spikes because their formulas were driven by replacement factors that rose gently with age more so than by discontinuities in the eligibility criteria. California's benefit enhancements since 1999 added 0.2 percent to the replacement factor at YOS = 30, creating a spike at that point. In addition, the maximum replacement factor was raised from 2.0 percent at age sixty to 2.4 percent at age sixty-three, which pushed out the age of negative accrual. Another enhancement was to allow the highest single year of salary to serve as the FAS after twenty-five years as opposed to the three-year average, a rather unusual feature that accounts for the minor spike at 25 YOS. In the case of Massachusetts, the enhancement in 2001 added $2\% \times (YOS - 24)$ to the replacement rate, for $YOS \geq 30$, which created the spike at 30 YOS. This also reduced the age of negative accrual by accelerating the date at which one reaches the 80 percent cap on the replacement rate. (By way of disclosure, one of us [Costrell] served in the Massachusetts administration at the time of this change and, along with other staff, recommended a gubernatorial veto [which was overridden by the legislature]. An account of that episode can be found in Costrell and Podgursky 2007a, along with further discussion of the effect on these diagrams of variations in state formulas.)

the years—it used to have a single spike at age sixty.[22] By contrast, recent changes in Texas's formula eliminated its spikes in an explicit cost-cutting measure. Since Texas's action was not a benefit enhancement, however, the change applied only to new hires; the vast majority of current teachers still face the incentives given by the double-peaked curve in figure 8.[23]

6. PENSION ACCRUAL PATTERNS AT DIFFERENT ENTRY AGES

Figures 1–8 assume entry at age twenty-five. This entry age is representative—we have estimated from a national sample of new retirees that their median entry age was 25–26.[24] However, it is important to consider variation in this pattern, especially with the rise of alternative paths into teaching as well as the traditional career interruptions of teachers.

At first blush, it might seem that the spikes would simply be displaced to the left or right depending on the entry age of the teacher. Things are not that simple, however, because the spikes depend in part on the interaction of age and YOS. For example, if a teacher is eligible for regular retirement at age sixty or YOS = 30, the magnitude of the spike when YOS hits 30 will depend on the difference between a teacher's age at that point and age sixty—the number of extra years of pension that 30 YOS obtains.

We illustrate some of these complexities by analyzing the Ohio pension formula. Figure 9 shows the pattern of deferred income over the careers of three entrant groups. The solid curve is the three-peaked pattern of the twenty-five-year-old entrant depicted previously in figure 3. The dotted curve represents a twenty-two-year-old entrant—an entry age that is actually a bit more common than age twenty-five. It too has three peaks, but they are moved three years to the left, appearing at ages forty-seven, fifty-two, and fifty-seven. The peak at age fifty-two is particularly pronounced: a twenty-two-year-old entrant will, in her thirtieth YOS, raise her pension wealth by the equivalent of almost four times her salary. This is a bigger spike than for the twenty-five-year-old entrant because her thirtieth YOS now qualifies her for three extra years of pension payments (starting at age fifty-two instead of fifty-five).[25] Finally, the dashed curve represents the thirty-year-old entrant. For her, the

22. See Costrell and Podgursky (2007b), figure 7 and Appendix A. More generally, this report contains more detail on the Ohio system.
23. Specifically, Texas, like Missouri, had a rule of 80, but effective with new hires after September 2007, eligibility was restricted to those reaching age sixty. In addition, Texas eliminated another feature that had allowed one to receive close to the full pension if one was close to fulfilling the rule of 80, once age = 55 and YOS = 20. These two features had accounted for the two spikes in figure 8's pre-2006 accrual curve.
24. We tabulated the ages of first-year teachers from the 2003–4 Schools and Staffing Surveys.
25. For the twenty-five-year-old entrant, the thirtieth YOS did not qualify her for any extra years of pension; her twenty-fifth YOS qualified her for pension at age fifty-five, but by the time she reached her thirtieth year she was already fifty-five years old. However, her thirtieth year did qualify her for the full phaseout of the penalty for early retirement.

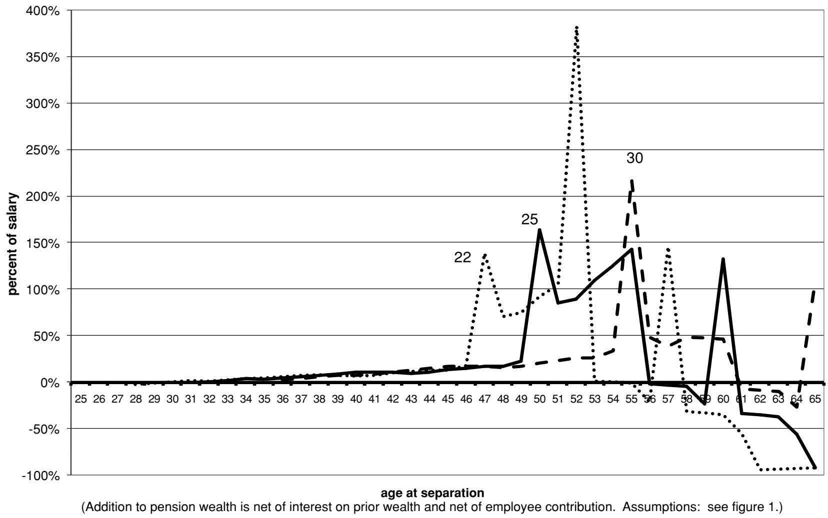

Figure 9. Deferred Income as Percent of Salary, Ohio: Entry Ages 22, 25, 30. Net Addition to Pension Wealth from an Additional Year of Teaching

first two peaks collapse into one at age fifty-five, and the final peak occurs ten years later upon her thirty-fifth YOS.

Our analysis of Ohio and other states suggests that the curves for twenty-five-year-old entrants are in fact indicative of the patterns for entry at the most common entry ages. The accrual patterns for older entrants, such as age thirty, are not quite as striking, but those for younger entrants, such as age twenty-two, are even more dramatic and more strongly tilted toward early retirement.

7. INCENTIVE EFFECTS OF PENSION SPIKES

There are two key incentives created by the spikes in pension wealth accrual—a pull and a push, as it were. First, teachers have a strong incentive to stay on the job—a pull—until they reap the benefit of the spikes. Even if a teacher is no longer suited to the job, it may well be worth "putting in one's time" for a few more years if it means collecting several hundred thousands of dollars in pension wealth.[26]

Second, once a teacher is beyond the spike and into the region of negative deferred compensation, the pension system creates a disincentive to stay on—a push out the door—even if one excels at the job. At this point, the pension system serves as a twofold tax on earnings, first by the required employee contribution and second by the negative wealth accrual; together these can easily

26. A recent survey conducted by the Education Sector (Duffett et al. 2008) sheds light on this point. Seventy-six percent of teachers agreed ("somewhat" or "strongly") with this statement: "Too many veteran teachers who are burned out stay because they do not want to walk away from the benefits and service time they have accrued."

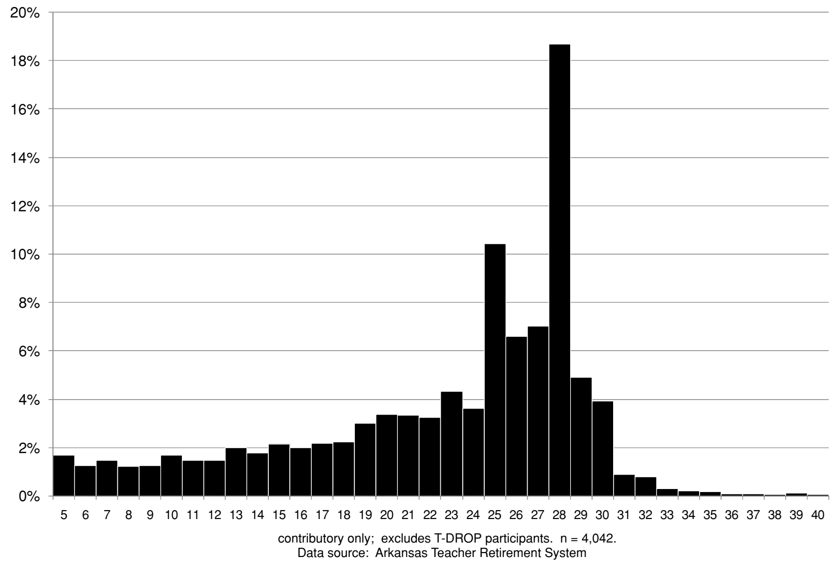

Figure 10. Distribution of Arkansas Retirements by Years of Service, 1998–2008

offset much or even all of one's salary. That is, the reduction in pension wealth from working an additional year and forgoing that year's pension payment can approach or exceed the teacher's take-home pay, in which case her total compensation is little or nothing.

There is ample evidence that such incentives affect behavior. Anecdotal evidence is commonplace of teachers (and others) timing their retirement decisions, at least in part, to features of the benefit formula. Pension systems routinely provide online pension calculators and retirement counseling to help their members do so. Labor economists have developed more systematic evidence of the behavioral impact of defined benefit pensions in other fields, particularly in the private sector (see, e.g., Friedberg and Webb 2005). There has been much less research on teacher pensions, but that which is available indicates strong incentive effects (Furgeson, Strauss, and Vogt 2006; Brown 2008; Podgursky, Ni, and Ehlert 2008).

A careful econometric analysis of the effect of these incentives (and changes in the plan parameters) for our set of states is beyond the scope of this article. However, the overall effect is seen in even simple tabulations of state retirement data. Consider the case of Arkansas. For most Arkansas teachers, the critical variable for pension benefits is YOS. As we saw in figure 4, there is typically a large spike in pension wealth accrual at 25 YOS, upon eligibility for early retirement, and accrual turns negative after eligibility for normal retirement at 28 YOS. Figure 10 gives the distribution of teacher retirements in

Arkansas by YOS for the period since these eligibility rules were set in 1997.[27] This figure provides clear evidence that teachers do indeed respond to the incentives embedded in the pension system. There is a spike in retirements at 25 YOS, consistent with the system's pull on those teachers who are approaching 25 YOS. And there is a particularly pronounced spike at 28 YOS, followed by a sharp drop in retirements at 29 YOS and beyond, consistent with the system's push to retire once pension wealth accrual turns negative.

This is not to say that the pension system is the sole determinant of teacher retirement decisions. As figure 10 indicates, 12 percent of retirees were willing to incur negative pension wealth accrual, teaching beyond 28 YOS, but not many were willing to stay on for long—only 3 percent stayed on after 30 YOS.[28] Also, 45 percent of retirees had fewer than 25 YOS. This figure includes late-starting teachers, or teachers with interrupted spells of employment, who taught until age qualified them for retirement instead of service. But it also includes many teachers who stopped teaching for any number of non-pension reasons before meeting either age or service requirements and thus deferring first pension draw until reaching the minimum age. Still, it is evident from figure 10 that the distribution of YOS cannot be understood without reference to the pension parameters.

Moreover, teachers surely respond to *changes* in pension parameters. Figure 11 depicts Arkansas' distribution of retirees under the previous set of parameters, 1984–96, when the YOS requirement for normal retirement was thirty. As one would expect, the major spike was at 30 YOS instead of 28.[29]

8. UNINTENDED CONSEQUENCES: EMPLOYMENT AFTER "RETIREMENT"

We have seen that teacher pension systems often have strong incentives built into them to encourage teachers to retire at relatively young ages. Clearly many teachers, even if they nominally "retire" in their fifties, will continue with labor market work of some sort for many years. Given concerns about teacher shortages and pressures from the No Child Left Behind Act to make sure that all classrooms are staffed with qualified teachers, it may be educationally

27. This set of teachers excludes participants in Arkansas' T-DROP system, discussed below. It is also restricted to those in that state's contributory system. Since 1999, all new full-time teachers were contributory, but prior to then teachers could choose instead to participate in a noncontributory system, with lower benefits. About one-third of recent non-T-DROP teacher retirees were noncontributory.
28. As stated in the previous note, this excludes participants in T-DROP, a program discussed below that allows teachers to continue teaching beyond the twenty-eight-year mark while attenuating the negative accrual.
29. There remains a spike at 25 YOS, consistent with the fact that the early retirement YOS was unchanged. The vesting requirement, however, was reduced from ten years to five in 1997, and this is reflected in the difference between 5–9 YOS retirements in figures 10 and 11.

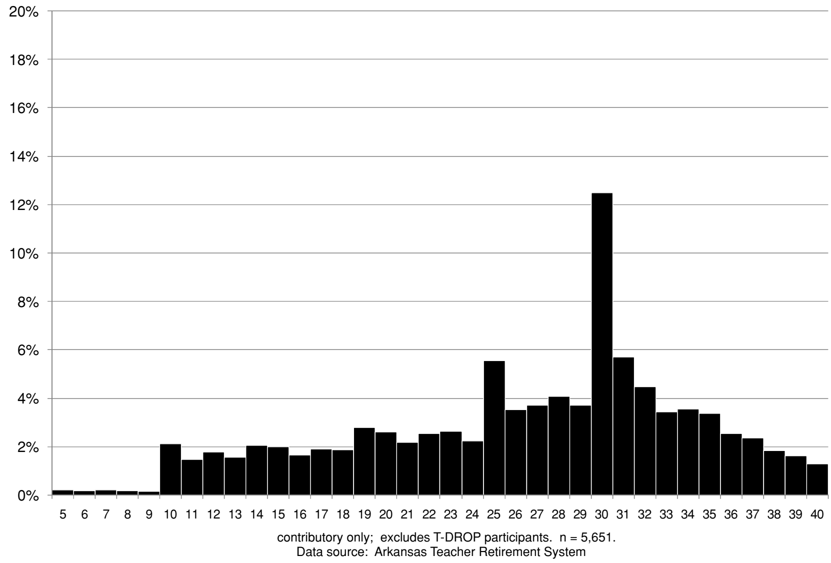

Figure 11. Distribution of Arkansas Retirements by Years of Service, 1984–1996

problematic for districts to nudge qualified and effective teachers out the door at such early ages. Not surprisingly, all these teacher pension systems have provisions allowing educators to continue to teach and collect their pension (a practice called double dipping). In many states, these provisions have been expanding. Here are some examples (see also Bragg 2003).

1. Part-time employment. All the pension systems considered here allow teachers who have retired to continue to work in covered employment on a part-time basis (without accruing additional benefits).
2. Employment in shortage areas. Many states permit retired educators to teach full time for a specified period of time in "shortage" fields.
3. Break in employment. Some states allow teachers to return to full-time employment and collect their pension after a specified break in service. In California the required break is twelve months. In Ohio, a retired teacher can return to work the next day but must wait two months before receiving pension benefits.
4. DROP plans. Many states have implemented deferred retirement option plans (DROPs). These permit teachers to continue working full time for a specified period of time (one to ten years), during which some portion of their pension check goes into what amounts to an individual retirement account. This prevents or attenuates negative pension wealth accrual, providing an incentive for teachers to "retire" and return to work.

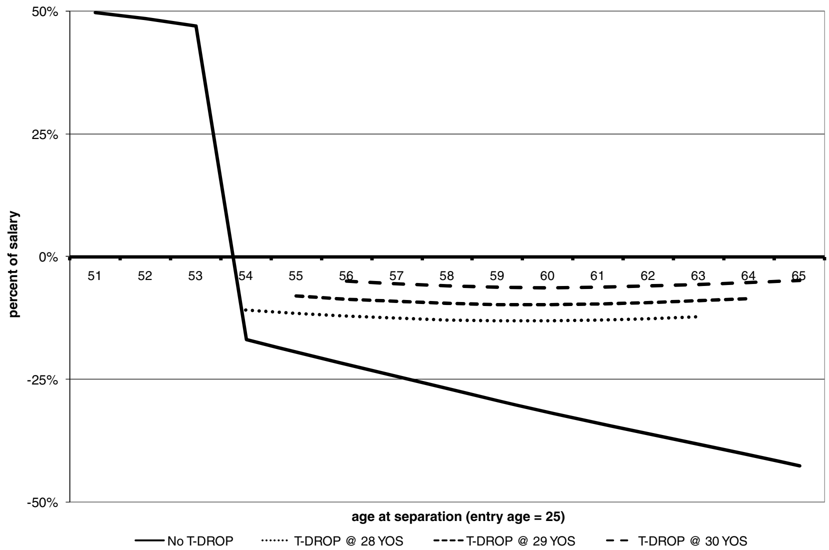

Figure 12. Deferred Income per Year, as Percent of Salary: Arkansas with T-DROP. Net Addition to Pension Wealth from an Additional Year of Teaching

Figure 12 illustrates the incentives under the Arkansas T-DROP plan. Under this plan, a teacher with 28 or more YOS can keep working after retirement for up to ten years, with 60–70 percent of her pension check going into a retirement account and accumulating interest until she actually leaves teaching. Figure 12 assumes that a teacher who entered at age 25 exercises this option after 28–30 years of service (at ages 53–55). Under these simulations, the T-DROP eliminates most of the pension penalty for continuing to teach beyond 28 years. (The curves are higher for entering T-DROP at 30 versus 29 versus 28 YOS because the deposit rates are 70 percent, 65 percent, and 60 percent, respectively.)

As would be expected, T-DROP participants work more years than non-T-DROP participants. We saw in figure 10 that only 12 percent of recent non-T-DROP retirees had more than 28 YOS. However, T-DROP entrants require a minimum of 28 YOS[30] and they put in an average of 4–5 years of additional teaching while in T-DROP. Taken together, the median T-DROP teacher works for 32–33 years. Adding those retirees from 1998–2008 who were in T-DROP to those who were not gives us figure 13. This figure shows the distribution of YOS plus, for T-DROP participants, years in T-DROP because these are also teaching years (but are not credited as YOS for pension benefits).

In comparing figures 10 and 13, one should be cautious in causally attributing all the longer employment spans to the T-DROP program; no doubt

30. From the program's inception in 1995 until 1999, the minimum was 30 YOS.

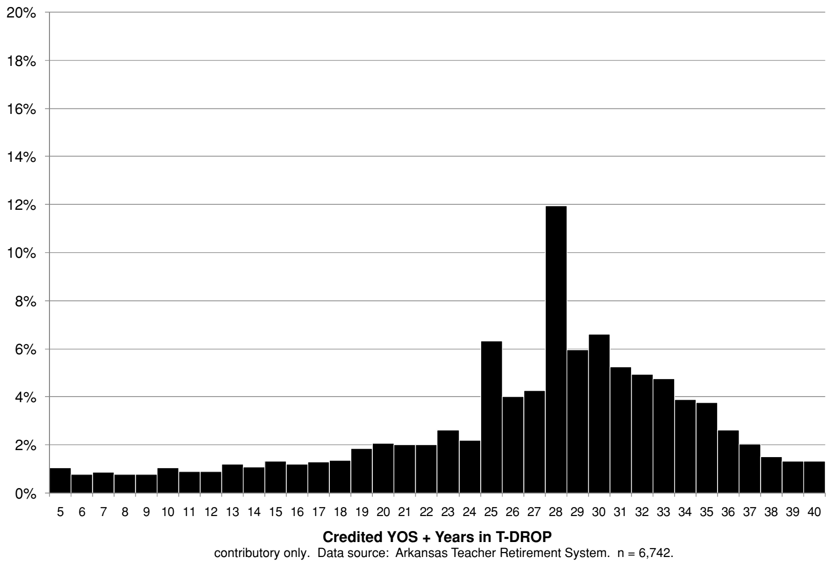

Figure 13. Distribution of Arkansas Retirements, with T-DROPS, 1998–2008

T-DROP participants self-select from among those who would work longer anyway. In this respect, figure 10 overstates the effect of the pension formula's incentives for early retirement by omitting the T-DROP participants. Figure 13, however, does not have that problem, and it still shows a behavioral response to the system's incentives, with unmistakable spikes at 25 and 28 YOS. As for the effect of T-DROP itself, the comparison of figures 13 and 10 is at least consistent with the intent of T-DROP to blunt some of the system's incentives toward early retirement.

In addition to these various re-employment provisions, there is no obstacle to retirees resuming employment in other fields, or even in teaching itself, by crossing a state line or a district boundary to work in a different pension system. For example, Missouri teachers in the state pension system can retire and work full time in the St. Louis or Kansas City (KC) systems, or a KC, Missouri, teacher can cross the border and work in KC, Kansas.

The net result of all of these practices is that the decision to retire (i.e., collect a retirement check) is not necessarily the same as a decision to quit teaching in public schools. Unfortunately, we are aware of no comprehensive national data on this topic. Limited data from a national survey conducted by the U.S. Department of Education suggest that at least 5 percent of the public school teaching workforce is also collecting a teacher pension. A longitudinal study of Missouri teachers found that 12 percent of teachers worked at least one year part or full time following retirement (Podgursky and Ehlert 2007).

The significance of these practices has not been fully explored. They have no parallel in the private sector because early retirement incentives there are always part of a downsizing effort, not one that offers re-employment. In teaching, by contrast, early retirement incentives have a completely different origin, namely, legislatively enacted benefit enhancements, typically under heavy union lobbying. Re-employment provisions are often a response to the unintended (if often predictable) problems created by these incentives. In other words, these provisions are ad hoc fixes to some of the perverse incentives created by enhanced pension spikes.[31]

Post-retirement employment blurs the distinction between current and deferred compensation. At the very least, this calls into question the meaning of published data on teacher compensation. In addition, as re-employment becomes easier, the incentive to retire at or near a pension spike becomes more pronounced—there is no downside if employment can continue. It might also be in the district's interest, if the pension costs are borne by the state, because new teachers cost the district less than older ones.[32] One might therefore expect that retirements would become further concentrated around the spikes, maximizing the total cost to taxpayers.[33]

9. MORE UNINTENDED CONSEQUENCES: HEALTH INSURANCE

Another consequence of early teacher retirement is a linked demand for retiree health insurance coverage. Since Medicare eligibility does not begin until age 65, teachers who retire in their fifties have a coverage gap of many years. In light of this, many school districts and states have extended health insurance coverage to retirees. Most retiree health insurance benefits have been paid by school districts out of current revenues (i.e., no trust fund was created to pay for these future liabilities, as was also the case originally with most pensions). Under new government accounting rules (GASB 43 and 45), benefit plans and employers must begin providing estimates of these liabilities in their annual financial statements. First hints at the figures are staggering. LA Unified, which provides complete health insurance coverage for all retirees, initially

31. In higher education, where DC plans (overwhelmingly TIAA-CREF) predominate, some colleges have encouraged phased retirement, wherein professors move to half-time employment status with a commensurate reduction in pay but the college continues to maintain contributions to the retirement plan based on full-time equivalent earnings. In general, partial retirement is easier to implement in a DC-type system. Also, as discussed below, in contrast to the typical teacher pension system, pension wealth never falls in a DC (or cash balance) system. Thus there is no work penalty or tax to offset. The costs and benefits of phased retirement are far more transparent (Clark 2004).
32. The logic of cost shifting also contributes to the phenomenon of buyouts, under which a district will offer additional financial incentives for teachers to retire. A consulting sector has developed to advise school districts on how to do this. (See www.epcinternet.com/, and especially the K–12 client list.)
33. For example, 63.9 percent of recent contributory Arkansas retirees, including T-DROP participants, clustered at 25–30 YOS.

estimated a $5 billion unfunded liability as of July 2004. The following year it was increased to $10 billion.[34] A recent report by the Cato Institute estimates that these unfunded liabilities of state and local governments could total $1.5 trillion (Edwards and Gokhale 2006; Deloitte Research 2006).

The consequences of early teacher retirements for publicly funded health liabilities have not been studied. However, to the extent that early retirement increases the total number of individuals—active and retired—relying on the school system for health insurance, the cost to taxpayers is increased.

10. OPTIONS FOR REFORM: CASH BALANCE OR DEFINED CONTRIBUTION PLANS

The underlying problem with traditional DB systems is their distortion of retirement incentives, stemming from the broken link between benefits and contributions. DC systems and cash balance (CB) plans restore that link. Many large corporations have switched to DC and CB plans over the last twenty years. Some public entities, including a few teacher pension systems (Ohio and Florida), have also started to offer DC- or CB-type options in their plans.[35]

CB plans are very similar to DC plans, in that both systems tie benefits closely to contributions. Under a CB plan, employees and employers contribute a certain percentage of earnings to an individual retirement account, the same as under DC. The main difference is that in a CB plan, the return is guaranteed by the employer (typically at a rate comparable to risk-free Treasury bonds), so the market risk is not borne by the employee. Often the debate over DB versus DC plans focuses on the shift of market risk from employer to employee rather than on retirement incentives. Since our subject here is the incentives, we focus first on CB plans, where employers continue to bear the market risk, so no market risk shifting occurs.

The incentive neutrality of CB plans with regard to age of separation can be simply depicted. In the net pension wealth accrual graphs (figures 3–9), the irregular curves would simply be replaced with flat lines, at a percentage given by the employer contribution (e.g., at 14 percent in figure 3). There are no spikes inducing teachers to stay to their mid-fifties and then to leave. Pension wealth never declines: if a teacher wants to work another year, the account grows by the contributions, plus the investment return. This can then be converted to

34. The factors that contributed to that increase were, in descending order of importance: (1) a change in the discount rate applied; (2) change in actuarial cost methods; (3) health care cost increases; (4) increased life expectancy and changes in retirement and turnover assumptions; and (5) one year of interest on the previous liability and additional benefits paid (Los Angeles Unified School District 2006).

35. One difficulty in evaluating these plans is that the DC option may not be on a level playing field with the traditional DB plan. For example, in Ohio the DB plan offers subsidized retiree health insurance but the DC plan does not.

an annuity (many CB plans do this automatically). If a teacher works another year, the starting annuity is increased in an actuarially fair manner because there is one less year of retirement to cover.

Such a retirement-neutral plan leaves the employee much more latitude to decide when to retire or switch careers, based on individual preferences. It also makes it easier for schools to retain effective teachers who might otherwise be driven by the pull-push incentives of pension spikes created by the heavy-handed traditional DB formulas. It is also fiscally more stable because benefits are closely tied to contributions. Unfunded liabilities do not arise so readily, and legislatures have less opportunity to enhance benefits by shifting costs to future generations of taxpayers and teachers.

Some of these features of CB also characterize DC plans because they too tie benefits to contributions. In fact, DC plans are totally immune to unfunded liabilities because there is no employer obligation beyond the contribution. On the other hand, the employee bears the risk of any investment decisions and also forgoes the benefit of institutional investment expertise. Also, since employee contributions are typically voluntary under DC plans, there is concern that employees will not save sufficiently for a secure retirement.[36] Finally, there is the concern that DC plan participants will tend not to annuitize their retirement balances, thereby incurring the risk of outliving one's assets. These concerns have led some to argue that DC plans might best be introduced as part of a hybrid plan that still includes a DB component. Note that many of these drawbacks can be avoided under CB, which is why many private employers switched to CB from the traditional type of DB plan.

A particularly relevant model for K–12 retirement reform may be found in higher education. Established in 1918, TIAA-CREF represents a popular and effective system that provides lifetime annuities and retirement security as well as transparency and complete mobility of retirement benefits to several million faculty, staff, and others in roughly 15,000 nonprofit institutions. Some private K–12 school teachers participate as well. While nominally a DC plan, TIAA-CREF has avoided many problems associated with such plans. Fees are very low, members have relatively few investment choices, and annuity payout options are the norm. By providing a guaranteed annual return combined with an annuity payout, TIAA more closely resembles a cash balance DB plan in that downside market risk continues to be borne by the plan (Greenough 1990).

In comparing traditional DB plans with contribution-based plans such as DC or CB, the issue of equity is also quite important. Traditional DB plans

36. This was reportedly the case for many teachers in West Virginia's shift from DB to DC. See Levitz 2008.

create wide variations in pension wealth between those who retire at or near the pension spikes and those who leave service early in their career. As we saw in figure 2, the former will receive a windfall of pension wealth that far exceeds the joint contributions, while the latter will not. Indeed, this feature creates a huge element of risk because an entering teacher often does not know in advance whether she will be a short timer, leaving the system with little pension wealth, or a career teacher receiving benefits that far outweigh the contributions. In this respect, CB and DC plans are *less* risky than traditional DB plans because teachers will receive benefits commensurate with contributions, regardless of length of career.

From a fiscal viewpoint, it is important to note that the low benefits for short timers, combined with high teacher contribution rates in some states, can help keep the state's average cost down in a traditional DB plan. In Massachusetts, for example, the normal cost of teacher pensions (i.e., leaving aside the legacy costs, which amortize unfunded liabilities) is 11.9 percent of payroll, and teacher contributions average 9.7 percent.[37] Assuming (as most actuarial reports do) that all employee contributions go to normal cost and none to amortize the unfunded liability, this leaves an employer contribution to normal cost of only 2.2 percent of pay.[38] This is less than the typical employer match on a DC or CB plan. The corresponding figures in our other states are higher: 4.0 percent in Texas, 4.8 percent in Ohio, 8.5 percent in Arkansas, 9.1 percent in Missouri, and 10.8 percent in California.[39]

In any case, whether the net employer normal cost is low or high, shifting to CB or DC and eliminating the tilt in benefits against short timers will almost certainly reduce benefits for "long termers" and may also be more expensive overall, depending on how generous the new program is. The point here is not so much the generosity of current plans but their idiosyncratic structure, resulting in a very uneven distribution of benefits and strong incentives to time career decisions to arbitrary plan parameters. In our view, that is the most compelling reason for considering pension reform.

37. For teachers hired after 2000, the contribution is 11 percent.
38. The vast majority of the employer's contributions in Massachusetts are to amortize the unfunded liabilities. For FY07, these legacy costs totaled 13.4 percent of payroll (author calculations based on PERAC 2007, pp. 8, 11).
39. The corresponding figures for employer contributions to amortize the unfunded liabilities are 2.6 percent in Texas, 8.2 percent in Ohio, 5.5 percent in Arkansas, 3.4 percent in Missouri, and 0.8 percent in California (ATRS 2008; Milliman Consultants and Actuaries 2007; PSRS/PEERS 2007; STRS Ohio 2007a; TRS 2007a). Note that all these calculations are simply a residual from total employer contributions rather than those that would be required to amortize the liability over some fixed horizon, such as the Government Accounting Standards Board (GASB) standard of thirty years.

11. CONCLUSION

Policy discussions about teacher recruitment, retention, and quality often focus on salary. However, pension policy also has important consequences for the teaching workforce. In the recruitment of young teachers, the attraction of pension benefits may seem distant and uncertain, especially because young workers often change jobs. The costs, however, are incurred from the start in contributions to the plan that can exceed 20 percent between employer and employee. Many young teachers, who are paying off student loans or attempting to start families and buy homes, might prefer more of their compensation up front rather than diverted into a system from which they may well never benefit. They may also be deterred by the fact that if they leave teaching after five or ten years, they will have accumulated little pension wealth, compared with some of their nonteaching peers in CB or 401(k) plans.

With regard to retention, it is difficult to imagine an efficiency rationale for the peculiar retirement incentives we find in these systems. Teachers are pulled to the pension spikes and then pushed out at relatively early ages by negative pension wealth accrual. The labor economics literature has developed the notion that DB pensions in the private sector might be interpreted as part of a mechanism to prevent shirking as one approaches the optimal date of separation (see Lazear 1979; Gustman, Mitchell, and Steinmeier 1994). Under this theory, age earnings profiles are steeper than the experience productivity profile, so workers are effectively posting a bond, inducing them to exert effort so they will not be fired before reaching late-career levels of compensation. On this view, rapid pension accrual is part of the steep age earnings profile, and the region of negative accrual serves the same purpose as mandatory retirement to prevent workers from overexploiting the gap between late-career compensation and productivity. This theory cannot persuasively apply to public school teaching because tenure virtually eliminates any fear of firing. Alternatively, the backloading of pension wealth accrual might make sense if research found very strong returns to worker experience. However, the vast majority of education production function studies find little return to experience beyond the first few years (Hanushek and Rivkin 2006). We are aware of no productivity evidence, for example, that could justify the differences in wealth accrual between a teacher with fifteen and one with twenty-five to thirty years of experience. We have also noted the (presumably) unintended byproducts of these DB systems in the form of growing retiree health insurance costs and re-employment of retirees (double-dipping).[40]

40. It is possible that the practice of double dipping is an efficient response to the constraints of the highly regulated personnel environment in which schools operate. Since tenure laws make it prohibitively costly to dismiss more senior teachers, pensioning them off en masse and then selectively rehiring

In addition, pension policy has powerful effects on K–12 school finance. Teachers who retire in their mid-fifties draw pension benefits for periods of time that are likely to equal or exceed their years of classroom service. A teacher retiring at age fifty-five with a $50,000 annual pension (indexed) has received an annuity valued at about $1 million. Moreover, she may well receive heavily subsidized retiree health insurance for a good while. Unless these benefits are offset by low benefits for short timers or high employee contributions, this can squeeze other parts of school budgets.

For all these reasons, we believe that school districts and states would be well advised to consider systems with smooth wealth accrual such as DC or CB plans. These systems are more transparent, tie benefits more closely to contributions, and do not penalize mobility or job shopping among young teachers. Given its record in higher education and private K–12, TIAA-CREF might be particularly useful in attracting career changers or young graduates in fields such as science and math, where 401(k) or 403(b) accounts are the norm (and where they are likely to encounter TIAA-CREF employers in future employment).

More generally, education policy makers should at least consider experiments that provide actuarially fair alternatives to traditional DB plans for new teaching recruits and evaluate their utility in the recruitment and retention of high-quality teachers. Even if most teachers continue to choose the traditional DB option, providing new recruits with a choice may, at the margin, help attract some of the most mobile and academically gifted candidates who have the best nonteaching options.

In addition, such policy experiments could help provide empirical evidence on the labor market effects of pension reforms. Such experimental studies, along with other nonexperimental research on existing teacher pension systems (exploiting variation over time and across states), could provide valuable insights into the potential of pension reform for improved teacher recruitment, retention, and quality.

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the better ones might make sense. (We thank Eric Hanushek for first pointing this out to us.) Indeed, the "burned-out" teachers presumably will be less inclined to work after retirement, so this self-selection might also act to raise productivity. Testing this thesis would require reliable teacher value-added estimates as well as pension and rehire data.

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REFERENCES

Arias, Elizabeth. 2007. United States life tables, 2004. *National Vital Statistics Reports* 56 (9): 1–6.

Arkansas Teacher Retirement System (ATRS). 2007. *Policy manual*. Available http://artrs.gov/index.php?option=com_content&task=view&id=127&Itemid=1. Accessed 9 September 2008.

Arkansas Teacher Retirement System (ATRS). 2008. *Comprehensive annual financial report, 2007*. Available http://artrs.gov/forms/atrs_10008_07_annual_report%202.pdf. Accessed 9 September 2008.

Asch, Beth, Steven J. Haider, and Julie Zissimopoulos. 2005. Financial incentives and retirement: Evidence from federal civil service workers. *Journal of Public Economics* 89 (2–3): 427–40.

Bragg, Connie. 2003. *Summary of public pension plans incorporating retention efforts: A state by state analysis of retention efforts within public pension plans*. Available www.nasra.org/resources/ncretentionstudy.doc. Accessed 9 September 2008.

Brown, Kristine. 2008. The link between pensions and retirement timing: Lessons from California teachers. Unpublished paper, University of Illinois, Champaign-Urbana.

California State Teachers' Retirement System (CalSTRS). 2007. *Member handbook: Your guide to CalSTRS benefits, 2007–2008*. Available www.calstrs.com/help/forms_publications/printed/2007mbrhb/mh_entire.pdf. Accessed 9 September 2008.

California State Teachers' Retirement System (CalSTRS). 2008. *Comprehensive annual financial report: A component of the state of California for the fiscal year ended June 30, 2007*. Available www.calstrs.com/Help/forms_publications/printed/currentcafr/cafrall.pdf. Accessed 9 September 2008.

Clark, Robert. 2004. Changing faculty demographics and the need for new policies. Paper presented at the TIAA-CREF Institute Conference, New York, April.

Costrell, Robert, and Michael Podgursky. 2007a. Efficiency and equity in the time pattern of teacher pension benefits: An analysis of four state systems. Working Paper No. 6, Urban Institute.

Costrell, Robert M., and Michael Podgursky. 2007b. *Golden peaks and perilous cliffs: Rethinking Ohio's teacher pension system*. Dayton, OH: Thomas B. Fordham Institute. Available http://edexcellence.net/doc/060707_pensions_report.pdf. Accessed 25 September 2008.

Costrell, Robert, and Michael Podgursky. 2009. Teacher retirement benefits. *Education Next* 9 (2): 58–63.

Deloitte Research. 2006. *Paying for tomorrow: Practical strategies for tackling the public pension crisis*. Available www.deloitte.com/dtt/cda/doc/content/us_pensioncrisis_research.pdf. Accessed 9 September 2008.

Diamond, Peter A., and Peter R. Orszag. 2003. *Saving social security*. Washington, DC: Brookings Institution Press.

Duffett, Ann, Steve Farkas, Andrew Rotherham, and Elena Silva. 2008. Waiting to be won over: Teachers speak to the profession, unions, and reform. Washington, DC: Education Sector Reports.

Edwards, Chris, and Jagadeesh Gokhale. 2006. Unfunded state and local health costs: $1.4 trillion. *Cato Institute Tax and Budget Bulletin* 40: October.

Friedberg, Leora, and Anthony Webb. 2005. Retirement and the evolution of pension structure. *Journal of Human Resources* 40 (2): 281–308.

Furgeson, Joshua, Robert P. Strauss, and William B. Vogt. 2006. The effects of defined benefit pension incentives and working conditions on teacher retirement decisions. *Education Finance and Policy* 1: 316–48.

Greenough, William C. 1990. *It's my retirement money—take good care of it: The TIAA-CREF story*. Homewood, IL: Pension Research Council, University of Pennsylvania.

Gustman, Alan L., Olivia S. Mitchell, and Thomas L. Steinmeier. 1994. The role of pensions in the labor market: A survey of the literature. *Industrial and Labor Relations Review* 47 (3): 417–38.

Hansen, Janet. 2008. Teacher pensions: A background paper. Unpublished paper, Committee for Economic Development.

Hanushek, Eric, Thomas Kain, and Steven Rivkin. 2004. Why public schools lose teachers. *Journal of Human Resources* 39 (2): 326–54.

Hanushek, Eric, and Steven Rivkin. 2006. Teacher quality. In *Handbook of the economics of education, volume 2*, edited by Eric Hanushek and Finis Welch, pp. 1051–78. Amsterdam: North-Holland.

Harris, Douglas N., and Scott J. Adams. 2007. Understanding the level and causes of teacher turnover: A comparison with other professions. *Economics of Education Review* 26: 325–37.

Ippolito, Richard A. 1997. *Pension plans and employee performance: Evidence, analysis, and policy*. Chicago: University of Chicago Press.

Kotlikoff, Laurence J., and Scott Burns. 2004. *The coming generational storm*. Cambridge, MA: MIT Press.

Kotlikoff, Laurence J., and David A. Wise. 1987. The incentive effects of private pension plans. In *Issues in pension economics*, edited by Zvi Bodie, John B. Shoven, and David A. Wise, pp. 283–336. Chicago: University of Chicago Press.

Lazear, Edward. 1979. Why is there mandatory retirement? *Journal of Political Economy* 87: 1261–84.

Levitz, Jennifer. 2008. When 401(k) investing goes bad. *Wall Street Journal*, 4 August.

Loeb, Susanna, and Luke C. Miller. 2006. A review of state teacher policies: What are they, what are their effects, and what are their implications for school finance? Getting Down to Facts Project, Institute for Research on Education Policy and Practice, Stanford University.

Los Angeles Unified School District. 2006. *Comprehensive annual financial report: Fiscal year ended June 30, 2006*. Available http://notebook.lausd.net/pls/ptl/docs/page/ca_lausd/lausdnet/offices/cfo_home/add_home/lausd_2006_cafr.pdf. Accessed 9 September 2008.

Massachusetts Teachers' Retirement System (MTRS). 2006. *Your MTRS benefits: A guide for active members*. Available www.mass.gov/mtrs/7pubs/77pdfs/actguids.pdf. Accessed 9 September 2008.

Milliman Consultants and Actuaries. 2007. *California state teachers' retirement system defined benefit program—2006 actuarial valuation*. Available www.calstrs.com/help/forms_publications/printed/2006_db_valuation_millimanreport.pdf. Accessed 25 September 2008.

Munnell, Alicia, and Steven Sass. 2008. *Working longer: The solution to the retirement income challenge*. Washington, DC: Brookings Institution.

Murnane, R. J., and R. J. Olsen. 1990. The effects of salaries and opportunity costs on length of stay in teaching: Evidence from North Carolina. *Journal of Human Resources* 25: 106–24.

National Association of State Retirement Administrators (NASRA). 2008. *Public fund survey*. Available www.publicfundsurvey.org/www/publicfundsurvey/actuarialfundinglevels.asp (registration required). Accessed 9 September 2008.

National Education Association (NEA). 1995. *Understanding defined benefit and defined contribution pension plans*. Washington, DC: NEA, Research Division.

National Education Association (NEA). 2006. *Characteristics of large public education pension plans*. Washington, DC: NEA.

Podgursky, Michael, and Mark Ehlert. 2007. Teacher pensions and labor market behavior: A descriptive analysis. Working Paper No. 4, University of Missouri, Columbia.

Podgursky, Michael, Ryan Monroe, and Donald Watson. 2004. Teacher pay, mobility, and academic quality. *Economics of Education Review* 23: 507–18.

Podgursky, Michael, Shawn Ni, and Mark Ehlert. 2008. Teacher pension incentives and labor market behavior: Evidence from Missouri administrative teacher data. Unpublished paper, University of Missouri, Columbia.

Public Employee Retirement Administration Commission (PERAC). 2007. *Commonwealth actuarial valuation report, January 1, 2007*. Available www.mass.gov/perac/valuation/2007commonwealth.pdf. Accessed 1 October 2008.

Public School and Education Employee Retirement Systems of Missouri (PSRS/PEERS). 2007. *Comprehensive annual financial report, 2007*. Available www.psrs-peers.org/Investments/2007%20annual%20report/2007%20cafr%20financial%20section.pdf. Accessed 1 October 2008.

Public School Retirement System of Missouri (PSRS). 2008. *Member handbook, 2008–09*. Available www.psrs-peers.org/psrs/2008-2009%20psrs%20handbook/service%20retirement.pdf. Accessed 7 October 2008.

State Teachers Retirement System of Ohio (STRS Ohio). 2007a. *Comprehensive annual financial report, 2007*. Available www.strsoh.org/pdfs/cafr2007/2007_cafr.pdf. Accessed 1 October 2008.

State Teachers Retirement System of Ohio (STRS Ohio). 2007b. *Service retirement and plans of payment*. Available www.strsoh.org/pdfs/brochures/15-126.pdf. Accessed 1 October 2008.

Stinebrickner, Todd. 2001. A dynamic model of teacher labor supply. *Journal of Labor Economics* 19 (1): 196–230.

Stock, James H., and David A. Wise. 1990. Pensions, the option value of work, and retirement. *Econometrica* 58 (5): 1151–80.

Teacher Retirement System of Texas (TRS). 2007a. *Comprehensive annual financial report, fiscal year ended 2007*. Available www.trs.state.tx.us/about/archive_annual_report/cafr_2007.pdf. Accessed 1 October 2008.

Teacher Retirement System of Texas (TRS). 2007b. *TRS benefits handbook*. Available www.trs.state.tx.us/benefits/documents/benefits_handbook.pdf. Accessed 1 October 2008.

U.S. Department of Education. 2008. *Digest of education statistics, 2007*. Washington, DC: National Center for Education Statistics. Available www.nces.ed.gov/programs/digest/2007menu_tables.asp. Accessed 1 October 2008.

Waring, M. Barton. 2008. Between Scylla and Charybdis: Improving the cost effectiveness of DB retirement plans. Paper presented at the Pension Research Council Symposium, The Future of Public Employee Retirement Systems, University of Pennsylvania, May.