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What Does the Literature Tell Us About the Possible Effect of Changing Retirement Benefits on Public Employee Effectiveness?

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What does the literature tell us about the possible effect of changing retirement benefits on public employee effectiveness?

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Abstract:

Proposals exist to change public employees' retirement benefits from defined benefit (DB) pensions. This could increase employee turnover and raise initial compensation. More experienced employees are replaced with less experienced ones, reducing effectiveness. But, new hires' effectiveness could increase with higher compensation. We simulate the net impact of these offsetting effects and find that there is a 60% to 70% chance that effectiveness will fall relative to the effectiveness that would have prevailed without benefit changes. There could be substantial transition costs, which could increase to 0.8% of payroll in the third decade after the switch for a typical DB pension.

Keywords: Public pensions; benefit design; public employee effectiveness.

JEL: H75; J33

I. Introduction

State and local governments experienced substantial budget shortfalls in the wake of the 2008-2009 recession. The fiscal demands on states have focused attention on public employee pensions since underfunded pensions – pensions that had less money than necessary to pay all promised benefits – required additional state contributions in a fiscally constrained environment.

Some commentators have suggested that states should use the crisis as an opportunity to replace their defined benefit (DB) pensions with alternative retirement benefits, such as defined contribution (DC) savings plans or cash balance plans – a hybrid between DB pensions and DC plans (Barro & Buck, 2010; Hansen, 2010; Costrell & Podgursky, 2009; McGurn, 2010).

Public employees typically receive DB pensions, whereby a retiree receives monthly benefits for the rest of her life. DB pensions defer part of an employee's compensation into the future, such that employees earn more benefits relative to their salary later in their careers than earlier. Deferring compensation creates incentives for employees to stay with one employer.

Alternative retirement benefits do not defer compensation, moving more of public employees' compensation to earlier stages in their careers. Alternative benefits would increase turnover among more experienced public employees relative to DB pensions and they may offer incentives to highly-qualified applicants who might not otherwise enter public service, particularly the teaching profession, to consider this career due to larger initial compensation.

Higher turnover and larger initial compensation work against each other with an uncertain outcome for average public employee effectiveness. Higher turnover means that more experienced public employees are replaced with less experienced ones, if there is a learning curve for public employees. Turnover thus could reduce average effectiveness. This drop in average effectiveness could be offset by an increase in new hires' effectiveness due to higher initial compensation. Whether average public employee effectiveness will increase or decrease will depend on the size of each effect -- turnover change, shape of the learning curve, and reaction to initial compensation changes -- and their interactions with each other.

The literature shows a lot of uncertainty related to each of these three factors. Ending deferred compensation tends to lead to higher turnover (Allen, Clark, & McDermed, 1993; Even & MacPherson, 1996; Ippolito, 1997; Nyce, 2007), but the estimates of the size of the turnover increase vary widely. Moreover, turnover will only reduce average effectiveness if there is a learning curve for public employees. A flat learning curve implies that turnover has no impact on average effectiveness since job leavers are replaced with equally effective entrants. It may take teachers -- the largest public employee group -- a year or two to reach their maximum effectiveness (Rivkin, Hanushek, & Kain, 2005), while others find that it takes up to a decade before they hit their full stride (Harris & Sass, 2011). And, an increase in new hires' effectiveness could offset the drop in average effectiveness following higher turnover, if effectiveness is positively correlated with initial compensation. Most studies show no link between initial salary and teacher effectiveness (Hanushek & Rivkin, 2006) and the effects that have been found tend to be relatively small (Cohn, 1968; Rivkin, Hanushek, & Kain, 2005; Hanushek & Rivkin, 2006; Perl, 1973). The impact of benefit changes on teacher effectiveness, as an example for the effect on public employee effectiveness, is a priori unclear, given the existing uncertainty over the relevant factors that determine average effectiveness changes.

We systematically analyze each factor's role and the uncertainty over each factor's size in determining effectiveness changes with alternative retirement benefits. We use teachers as an example since they are the largest share of the public workforce and their compensation and effectiveness has been more widely studied than that of other skilled public employee groups. We use a simulation model to analyze the impact of changing retirement benefits on average teacher effectiveness. We account for uncertainty by using randomly selected parameter values -- based on the existing literature -- for turnover, the shape of learning curve, and the correlation to initial compensation in a Monte Carlo simulation. We then calculate the probability that average teacher effectiveness will improve and the expected average change in teacher effectiveness, following a change in retirement benefits. We confirm our results by conducting several robustness tests to address the effect of our parameter assumptions, each individual factor, and policy scenarios on the estimated outcomes.

We hold several factors constant. For one, we assume that teacher characteristics other than effectiveness are randomly distributed and thus are not part of our simulation model of average teacher effectiveness. We also calculate the average effectiveness for a state. We assume that the work environment does not change with changing benefits and thus does not enter our simulation model. We finally assume that states will use the same effectiveness measure under alternative benefits as they would under a DB pension, so that we can calculate the average effectiveness change without having to specify the exact effectiveness measure.

We bias our simulations in favor of alternative retirement benefits in calculating the probability of increasing teacher effectiveness and average change in teacher effectiveness. We ignore, for instance, costs associated with higher turnover and transition costs, so that our simulations show more compensation under alternative benefits than would be realistically the case. Our results are thus a lower bound estimate of the risk associated with changing public employee benefits

Our research contributes to the literature in several ways. This is the first systematic evaluation, to our knowledge, of the effect of changing retirement benefits on teacher and thus on public employee effectiveness. Second, we account for the uncertainty over the key factors that influence teacher effectiveness, when benefits are changed, and thus quantify the risk of lower average employee productivity to public employers. Third, we specifically evaluate the effect of simultaneous benefit cuts and benefit changes on teacher effectiveness to estimate the associated risks to employers. And fourth, we estimate the transition costs of replacing existing DB pensions to offer a comparison between risks and costs.

The rest of our paper is organized as follows. Section II discusses the relevant background and literature. Section III formalizes the key relationships and assumptions to measure average teacher effectiveness. Our simulations are described in Section IV and their implications are discussed in the conclusion in Section V.

II. Background and literature review

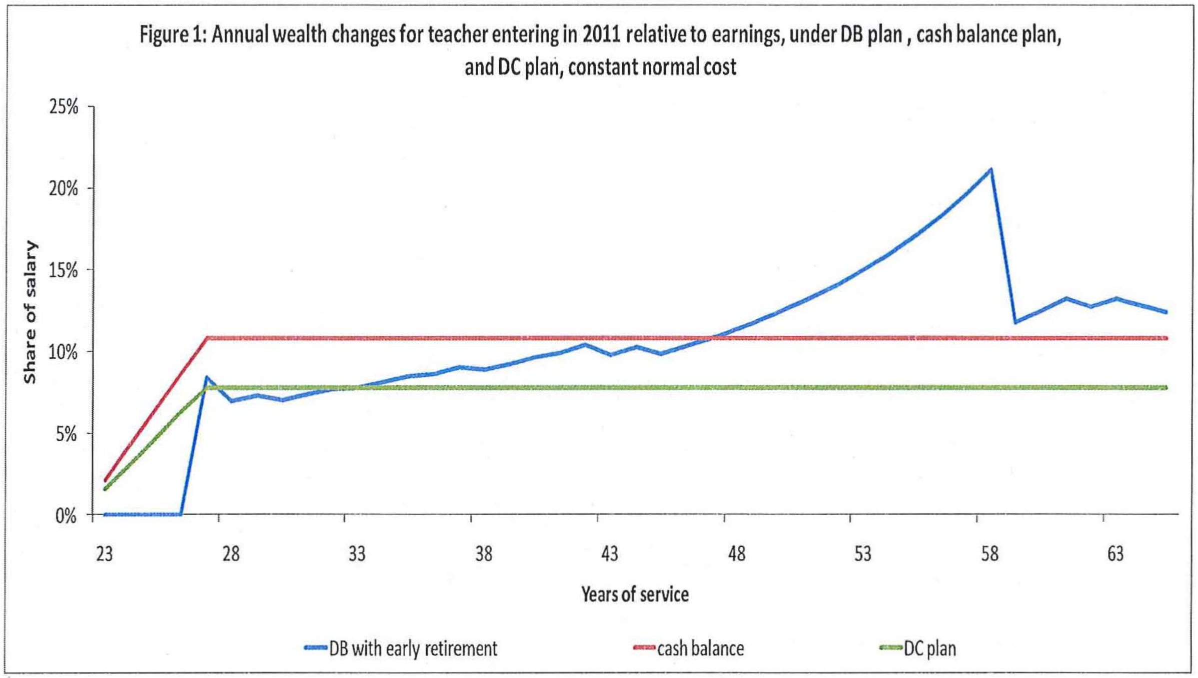
The fiscal crisis of state and local governments, starting in 2008, coincided with public pension plans' underfunding (Munnell, Aubry & Quinby, 2010). Munnell et al. (2008), for instance, report that 39% of public pensions had less than 80% of their liabilities in assets in 2006.

Retirement benefits in teacher compensation

Retirement benefits are a substantial part of teacher and public employee compensation. Bender and Heywood (2010) show that benefits averaged of 32.7% of compensation for the public sector between 2004 and 2008 and that 6.5% of compensation were retirement benefits.

Teacher retirement benefits are typically DB pensions. Teachers receive lifetime retirement benefits, based on years of service, age, and final earnings. They often have to work for at least five or more years before becoming vested, i.e., before they earn any claim to retirement benefits (National Education Association, 2010). Benefits are financed by employee and employer contributions in addition to investment earnings on accumulated assets. Employee contributions are made at a fixed rate, while employers bear the risk if plans have too few assets to pay all promised benefits and if more employer contributions are necessary.

DB pensions make up a smaller share of total compensation earlier in employees' careers than later (Cahill & Soto, 2003; Clark & Schieber, 2000; Johnson & Uccello, 2001). Figure 1 shows an illustrative example of the annual benefit accrual under a typical teacher DB pension (details below). The x-axis shows the years of service and the y-axis shows the annual amount of retirement benefits relative to a teacher's salary that she earns with a DB pension, cash balance plan, or DC plan. Teachers earn an increasing amount of retirement benefits, relative to earnings, until they reach early retirement (e.g., after 35 years of service). A teacher, for instance, may work for 35 years in a school until she reaches age 58, assuming she started when she was 23 years of age, and she may earn 2.0% of her final salary annually as a benefit. With a final salary of $90,000, she would receive an annual DB pension of $63,000 (equal to 35 times 2.0% times $90,000), until she dies, if she retired at age 58, after 35 years of service. Teachers can still earn additional benefits after the early retirement incentive has expired, but the annual accrual is less than during the years leading up to the early retirement age.



Notes: All figures are in percent of payroll. See text for description of calculations.

Deferring compensation with DB pensions provides an incentive for employees to remain with a particular employer. DB pension plans are hence good for retention (Friedberg & Owyang 2005; Gustman, Mitchell & Steinmeier, 1994; Nalebluff & Zeckhauser 1984). DB pension plans also consistently reduce employee turnover (Allen, Clark & McDermed, 1993; Even & MacPherson, 1996; Ippolito, 1997; Munnell, Haverstick & Sanzenbacher, 2006; Nyce, 2007).

DB pensions generally offer early retirement incentives at the far end of a teacher's career to incentivize leaving once one is eligible for retirement, after which point teacher effectiveness may ultimately decrease. Employees earn smaller additional benefits after the early retirement age than before in a DB pension (Clark & Schieber, 2000).

There are several proposals to use defined contribution (DC) or cash balance plans instead of DB plans (Barro & Buck, 2010; Hansen, 2010; Costrell & Podgursky, 2009). Table 1 summarizes the characteristics of each retirement benefit type. DC plans are retirement savings plans, which are more common as the primary retirement benefit in the private sector than in the public sector. Employees and employers contribute a fixed percentage of earnings each year. The money is allocated to an individual account, with employees deciding how the funds are invested and shouldering the risks associated with these decisions under a typical private sector DC plan.

Cash balance plans are still DB plans, but they resemble DC plans in key aspects. Each worker receives a notional (hypothetical) account, even though all funds are invested as one large pension pool. An employee's notional account is credited with an amount equal to a fixed share of a worker's earnings each year and the account balance increases annually at a pre-determined interest rate, the interest credit. The plan is financed by employer and employee contributions and investment earnings. Employers again bear the risk of too-low assets. Notional account balances can be rolled over into other retirement plans when a teacher switches jobs (Cahill & Soto, 2003; Clark & Schieber, 2000; Johnson & Uccello, 2001).

The benefits earned with cash balance or DC plans equal fixed earnings shares, which are higher earlier in a career and lower later in a career than with DB pensions (see Figure 1 above). DC and cash balance plans hence may change recruitment and retention incentives, possibly attracting more effective teachers and raising turnover among less effective ones.

Table 1
Characteristics of typical pension plans, by plan type

Characteristic	Defined benefit plan		Defined contribution plan
Plan type	Traditional	Cash Balance	403(b) plans
Participation	Automatic	Automatic	Voluntary
Contribution	Employer and employee	Employer and employee	Employee with occasional employer matches
Investments	Determined by employer	Determined by employer	Typically determined by employee
Withdrawals	Annuity	Annuity or lump sum	Lump sum
Rollovers before age 65	Not permitted	Permitted if lump sum option exists	Permitted
Benefit guarantee	Often constitutionally guaranteed	Often constitutionally guaranteed	None
Early retirement benefits	Common	Uncommon	Unavailable
Vesting	Up to a decade or more	Typically shorter than in traditional pension plans	Typically immediate for employee contributions and often immediate for employer contributions

Notes: Cash balance plans typically do not exist in the public sector. The description thus relies on typical characteristics of private sector cash balance plans. Also, defined contribution plans are generally supplemental retirement savings plans in the public sector and thus tend to be voluntary plans.

Teacher pay, teacher experience, and student outcomes

Teacher quality is a critical contributor to student achievement. A debate persists, though, about the definition of teacher quality. Teacher quality, for example, has been measured by teachers' qualifications, most notably codified through the No Child Left Behind Act of 2001 (NCLB). NCLB originally defined highly qualified teachers as those with bachelor's degrees, full state certification, and demonstrated competency in the core academic subjects that they teach.

This definition of teacher quality has been challenged by those who emphasize "teacher effectiveness". Teacher effectiveness measures teachers' demonstrated ability to raise student achievement, typically measured by standardized exam results. Adherents to this point of view have proposed several policy changes pertaining to teacher employment, including retirement benefits, as we discuss below, and the elimination of additional pay for teachers with a Masters degree (Duncan, 2010; Gates, 2010) due to the lack of evidence that having a Masters degree raises effectiveness (e.g., Larsen, 2010).

The prioritization of effectiveness over qualifications also has implications for how teachers' experience is viewed. Greater emphasis should be given to beginner teachers, in this view, if there is a comparatively flat learning curve with small returns to experience, measured by student outcomes. School districts' efforts to dissolve "last in, first out" (LIFO) policies have hinged, for instance, on the assertion that teachers' effectiveness is not strongly predicted by experience. The disproportionate risk to beginner teachers under LIFO policies coupled with their already high rate of attrition from the teaching profession (Ingersoll & Smith, 2004; Keigher, 2010) raises concerns for those, who view the entry of new talent as a gateway to increased teacher effectiveness and higher student achievement.

The policy goals then are better recruitment and retention of people into the teaching profession who could become effective teachers. The proposal to raise initial compensation levels through changed retirement benefits earlier in teacher careers pursues these goals. Hanushek and Rivkin (2006), though, point out that it is difficult to disentangle the relationship between teacher salaries and student outcomes since teacher pay is the result of several factors. They conclude, based on a thorough review of the existing literature, that only about 20% of studies show a statistically significant and positive relationship between teacher salaries and student outcomes.

Teacher experience, however, has been shown to matter for student outcomes, possibly more so than teacher pay. Hanushek (1997, 2003) concludes that between 30% and 40% of empirical studies find a statistically significant and positive relationship between experience and student outcomes. There seems to be a non-linear relationship between experience and student outcomes, such that teachers with just a few years of experience perform much worse than more experienced teachers (Rivkin, Hanushek, & Kain, 2005; Hanushek et al., 2005; Harris & Sass, 2011). The break point may be as low as one or two years or as high as ten years.

Costs of retirement plan designs to individuals

The effect of retirement plan changes on teacher effectiveness partially depends on potential additional costs associated with alternative benefits since less money may be available for compensation.

First, the DC plans may have higher fees than DB pensions. Fees are higher by 0.5% to 1.0% of assets for DC plans than for DB pensions (CII, 2006; Weller & Jenkins, 2007). Second, rates of return may be lower with alternative benefits than in DB pensions. Cash balance plans may need to hold more cash to accommodate withdrawals from teacher leaving more quickly, which lowers the average rate of return. And, DC plans are invested with a fixed retirement date in mind, such that individuals reduce risk towards the end of their career, foregoing potential earnings and lowering their savings by 5% after a 40-year career (Almeida & Fornia, 2008). Third, the loss of protections from market, idiosyncratic, and longevity risk with a DC plan compared to a DB pension lowers benefits by 41% after a 40-year career compared to DB pensions (Almeida and Fornia, 2008).

III. The basic model of teacher effectiveness and retirement plans

We use a basic model linking retirement benefits and teacher effectiveness to simulate the likely effect of changing retirement plans. Initial teacher effectiveness is a function of teacher compensation:

$$p_{i1} = F(s_1(CONT); x_i; y_j) \qquad (1)$$

where p_{i1} is the effectiveness of teacher i in her first year. It is positively correlated with initial compensation, s_1, which depends on the annual retirement benefit, $CONT$, a vector of individual characteristics, x_i, and a vector of work environment characteristics, y_j. Initial compensation tends to be higher under a cash balance and DC plan than under a DB plan since annual retirement wealth creation is no longer deferred. Initial teacher effectiveness should thus be greater under a cash balance or DC plan than under a DB pension.

Annual retirement wealth increases, $CONT_{it}$, are defined as a function of years of service, ten_i, the retirement plan's earnings, ror_t, the plan's costs, $fees_t$, and employee turnover, to_i:

$$CONT_{it} = NCOST_{it}(ten_i; ror_t; fees_t; to_i) \qquad (2)$$

We assume that the amount available for retirement benefits, so-called normal costs, $NCOST_t$, is fixed as share of earnings for all benefit types. It seems unlikely that states and localities will raise retirement spending, e.g. to cover higher costs, considering that the trend has been towards less retirement benefit spending for some time (Pew, 2011). The total benefit amount can only increase if the administrative and other ancillary costs, such as early retirement benefits, of an alternative benefit decrease relative to DB pension costs.

The link between benefits and employee tenure for DB pensions is defined as:

$$CONT_{it} = 0 \qquad \text{if } ten_i < tmin \qquad (2a)$$

If a teacher is not yet vested, i.e. her tenure is less than the minimum years required, *tmin*. The normal cost for vested employees is:[1]

$$CONT_{it} = \frac{a * salary_{it} \prod_{j=t}^{T} (1 + sg_{ij})}{(1 + r_t)^{(T-t)}} * P(\mathrm{Re}tAge \mid age_i) * AF \qquad \text{if } ten \geq tmin \qquad (2a')$$

[1] We use the prospective unit credit method to calculate normal cost to illustrate additional retirement wealth for teachers in a given year. Public pensions typically use an entry-age normal cost calculation for their pension plans. This method, though, obscures the additional retirement wealth that each cohort of teachers earns each year.

Once teachers are vested, the benefit is the product of a multiplication factor, a, the expected final salary, the probability of surviving to the retirement age $P(RetAge|age)$, the annuity factor, AF, and the inverse of the discount factor $(1+r)^{(T-t)}$, to arrive at the present-day value of the future benefit. The final salary is the current salary, $salary_t$, grown to the final year of service, T, at the annual salary growth rate, sg_{it}. The annuity factor, AF, is the amount that a pension plan will need at age 65 to pay one dollar as annuity.

We assume a typical teacher DB pension for this model (NEA, 2010). Vesting happens after five years. This favors cash balance and DC plans, where we allow for phased vesting, shifting more compensation towards earlier years in a teacher's career than under a DB pension. We also assume a multiplication factor of 2.0%, which is slightly above the average multiplication factor in teacher pensions (NEA, 2010). A smaller factor implies lower normal costs and thus less compensation to attract potentially more effective teachers. We further assume that benefits increase with inflation equal to 2.5% annually. A lower inflation rate would again decrease the normal costs, lowering initial compensation changes under alternative benefits. We next assume full benefit receipt after working for 35 years as early retirement benefit. We also set a nominal discount rate of 7% per year,[2] which is at the lower end of the discount rates assumed by public pension plans. A higher discount rate would reduce the normal cost of a DB pension. And, we assume that the annuity factor for the benefits paid under a DB pension is decided by the mortality assumptions for healthy annuitants in the RP-2000 mortality tables (SOA, 2000). We take the simple average of the mortality rates of women and men each year to arrive at an overall mortality rate. We thus calculate an annuity factor of 13.32 at age 65. The plan will have to have \$13.32 on hand for each dollar promised as annual benefit paid monthly. Finally, we assume a starting salary of \$45,000 in 2011 and a salary schedule following the steps of the New York City school system (NYC, 2010). We assume that the salary steps increase with inflation. Alternative salary schedules have no material effect on our simulations as the results depend on initial salary changes, not on the subsequent salary progression.

The annual retirement wealth accruals for cash balance are defined as:

$$CONT_{it} = 0.2 * ten_i * b * salary_{it} * \frac{(1+ic)^{T-t}}{(1+r)^{T-t}} \quad \text{if } ten_i < tmin \tag{2b}$$

And

$$CONT_{it} = b * salary_{it} * \frac{(1+ic)^{T-t}}{(1+r)^{T-t}} \quad \text{if } ten_i \geq tmin \tag{2b'}$$

The employee earns a pay credit, b, equal to a fixed salary share after vesting and a reduced pay credit before vesting. The pay credit then grows until retirement at a predetermined interest

[2] Some have argued that the true discount rate for public DB pensions should be much lower (Novy-Marx & Rauh, 2011). We model a typical teacher plan and there is no indication that states will change their discount rates. A lower discount rate would increase the costs of existing benefits and, more importantly, of the existing underfunding and thus make less money available for alternative retirement benefits.

credit, *ic*, and is discounted to the present at the discount rate. The annual wealth accrual under a DC plan differs from this calculation only in that there is no interest credit and no discount rate, i.e. both rates are equal to zero and the last expression equals one.

For cash balance plans, we assume that the interest credit is equal to the discount rate and that the discount rate reflects the actual long-term rate of return on pension plan assets for a DB plan, as we discuss in the appendix. We next assume that the plan sets aside an additional five percent of its assets in cash to accommodate in-service lump sum withdrawals, thus lowering the interest credit by 0.35% (0.05*0.07) annually. We also assume that the pay credit is linearly phased in over five years, such that teachers receive 20% of the pay credit in their first year, 40% in the second year, and so on.

We make one more assumption for the DC plan contribution rate, equal to b in equation (2b) and (2b'). DC plans are associated with substantially higher costs than a DB pension due to lower rates of return following the loss of intergenerational smoothing, and lower insurance protections (Almeida & Fornia, 2008). We specifically assume that there is a cost difference between DC plans and DB plans and cash balance plans equal to 46% of the accumulated savings after 40 years (Almeida & Fornia, 2008), equal to 50% of the contribution rate.

Teacher effectiveness after the first year may be a function of experience, up to a maximum number of years. This defines the learning curve for teachers:

$$p_{it} = \alpha ten_i + \beta F(x_i; y_i) \qquad \text{if } t>1 \qquad (3)$$

The tenure coefficient, α, is defined as follows:

$$\alpha > 0 \qquad \text{if } T>1 \ \& \ T<\text{tmax} \qquad (3a)$$

$$\alpha = 0 \qquad \text{if } T \geq \text{tmax} \qquad (3a')$$

Where *tmax* denotes the first year a teacher reaches her maximum effectiveness, which then stays constant for the remainder of a teacher's career.[3]

The combination of equations (1), (2), and (3) generate a state's average teacher effectiveness:

$$\overline{p} = \frac{\sum_{t=1}^{T} \overline{p}_t N_t}{N} \qquad t=1,\ldots,T \qquad (4)$$

Where N_t is the number of teachers in a career year and N is the total number of teachers in a school. The average teacher effectiveness is lower, if it takes teachers on average longer to reach the year of their maximum effectiveness and if the gap between the initial average teacher effectiveness and average maximum effectiveness is hence larger.

[3] It is possible that teacher effectiveness may eventually drop off, but there is little empirical evidence for that.

The average teacher effectiveness also depends on the distribution of teachers across all years of a teacher's career. A larger share of less experienced teachers lowers average teacher effectiveness since a larger number of inexperienced teachers will be multiplied by a lower average teacher effectiveness than if the share of less-experienced teachers is smaller. Each year's employment, after the first year, is defined as the total number of employees divided by the number of teacher cohorts and multiplied by the cumulative turnover for each cohort, to_k:

$$N_t = to_k \frac{N}{(age\max - age\min)} \qquad \text{if (agemax-agemin)>1} \qquad (5)$$

The employment in the first year is defined as:

$$N_1 = N - \sum_{t=2}^{T} N_t \qquad (5')$$

All net leavers are replaced by new hires into the first cohort. Cumulative turnover at any given year is the product of each year's turnover, specific to that year of a teacher's career:

$$to_t = \prod_{k=age\min}^{t} to_k \qquad (6)$$

And, the annual turnover is positively correlated with future expected compensation:

$$to_k = F(age_t; comp_t; y_j) \qquad (6')$$

Where to_t is the cumulative turnover at period t, depending on *age* and future expected compensation. Turnover should be higher under a cash balance plan or DC plan than under a DB plan since future expected compensation is often lower due to the lack of deferred compensation.

We assume that teacher turnover follows the pattern described in Harris and Adams (2007) for a DB pension. Teacher turnover is relatively high when teachers are in their twenties, reaches its lowest point, when they are in their early 40s, before rising again. Lower average turnover to start with would imply higher average teacher effectiveness with DB pension plans, as discussed further below. We also assume that net in-migration – the difference between new teachers being hired on and existing teachers becoming disabled or dying – equals 2.55% of total cohort employment between age 30 and age 60. The resulting average age of teachers in this plan is 41.7 years – close to the average age of 41.8 years found in Harris and Adams (2007).

We also assume a higher turnover with alternative benefits. A higher turnover means a greater share of younger teachers who earn less than older teachers and who are not fully vested and thus receive fewer benefits. Teacher turnover is likely to increase under a cash balance plan relative to a DB plan, consistent with the literature (Allen, Clark & McDermed, 1993; Even & MacPherson, 1996; Ippolito, 1997; Munnell, Haverstick & Sanzenbacher, 2006). The lack of pensions increases turnover on average by 22.0% at the low end (Allen, Clark & McDermed, 1993), which we use as the low estimate for the switch to a cash balance plan. We also assume that the turnover increases by 28% at the low end in the switch to a DC plan (Nyce, 2007). Higher turnover rates will reduce average teacher effectiveness as we discuss in detail below.

We normalize average teacher effectiveness, so that the maximum teacher effectiveness under a DB plan is set equal to 100%. The average teacher effectiveness at any year in a career is then expressed as share of the maximum effectiveness under a DB plan. We do not specify the exact measure of teacher effectiveness. The design of retirement benefits may affect teacher effectiveness, but not how it is operationalized. We should see similar impacts of changing retirement benefits on teacher effectiveness, regardless of how effectiveness is measured.

We make two more simplifications. First, we assume that individual characteristics are randomly distributed in each teacher cohort and thus eliminated when we calculate average teacher effectiveness, given the associations between teacher attributes and effectiveness (e.g., Rice, 2003). This allows us to ignore teachers' individual characteristics as determinants of average effectiveness. Second, we consider effectiveness changes under varying benefits in one state. The work environment – a critical determinant of turnover – is independent of retirement benefits and thus has no bearing on our simulations. Teachers' decisions to leave are frequently due to work-life quality issues, such as sense of support by school leadership, role in decision-making, and school safety or classroom management issues (e.g. Loeb, Darling-Hammond, & Luczak, 2005; Smith & Ingersoll, 2004; Somech, 2010). Our approach is akin to a regression, where we measure the effect of benefits on key variables – experience, compensation, and turnover – that impact teacher effectiveness, while holding other factors constant.

We focus on the role of compensation, experience, and turnover on teacher effectiveness. Average effectiveness is positively correlated with compensation. The elimination of deferred compensation can increase teacher effectiveness by shifting pay to earlier years in a teacher's career. Effectiveness is also negatively correlated with turnover. Alternative retirement benefits may increase turnover by eliminating the incentive to stay on the job, thus lowering average effectiveness since more experienced teachers are replaced with less experienced ones. And, effectiveness is also negatively correlated with return on experience. The impact of turnover on average effectiveness is greater if the return to experience is larger, marking a negative correlation between the two variables. Less experienced teachers will take longer to reach maximum effectiveness with a higher return to experience. Higher turnover shifts the weight within the teaching workforce to inexperienced teachers, lowering average effectiveness especially if the gap between inexperienced and experienced teachers is large.

IV. Simulation analysis

We evaluate the potential effects of different retirement benefits on teacher effectiveness in several steps. First, we calculate a typical teacher DB pension plan's normal cost, a cash balance plan's pay credit, and a DC plan's contribution rate, based on our assumptions. This calculation shows the differences in initial compensation with alternative benefits, without accounting for potential transition costs. Second, we use Monte Carlo simulations to calculate the probability of improving teacher effectiveness and the average change in teacher effectiveness after switching retirement benefits. This will account for the uncertainty associated with each input variable. Third, we discuss the role of experience, effectiveness, and turnover separately in affecting the chance of improving average teacher effectiveness. This will both help to inform our policy discussion by showing which factors have the largest adverse effect on the estimated outcome and serve as robustness test to show how our original estimates change when one of the input factors is held constant. Fourth, we provide estimates of the impact on teacher effectiveness if employers cut retirement benefits and switch from DB plans to alternative benefits in a fiscal crisis. This will serve to highlight the risks associated with changing benefits under different simulation scenarios. And finally, we calculate the transition costs from a DB pension to alternative retirement benefits to highlight the fiscal impact of such a policy change and allow a comparison to the potential risks.

Normal cost of DB pension plan, pay credits for cash balance plans, and DC plan contributions

Our typical teacher DB pension's normal cost averages 10.25% of earnings, based on the assumptions laid out in the previous section and summarized in Table 2. This translates into a cash balance plan's pay credit of 10.78% of earnings (Table 2). The pay credit is higher than the normal cost of the DB plan because a larger share of the workforce is not yet vested and thus receives less than the full contribution. And, the DC plan's contribution rate is 7.79% of payroll (Table 2), again holding total normal cost constant relative to DB pensions, while ignoring transition costs. That is, the three plans costs the same, after a switch has been completed and there are no longer any transition costs, which we discuss below in greater detail.

Table 2
Alternative plan designs with constant costs to earnings

Characteristics	DB plan	Cash balance plan	DC plan
Multiplier	2% multiplier of average of final three years of pay	--	--
Vesting	Five-year cliff vesting	Five-year phased vesting	Five-year phased vesting
Full retirement age	65	65	65
Early retirement	Full benefits at any age after 35 years of service	None	None
Additional costs	--	Higher cash holdings	Higher fees, lower rates of return due to loss intergenerational smoothing, loss of insurance protections
Normal cost as share of payroll	10.25%	10.25%	10.25%
Turnover	--	22% increase	28% increase
Average age	41.2	38.3	37.8
Pay credit/contribution	--	10.78% of payroll	7.79% of payroll

Calculating the probability of teacher effectiveness gains and losses

We estimate the chance of improving teacher effectiveness with a switch to alternative retirement benefits from a DB pension using a simulation model (see Table A-1 in the appendix for details of our input parameters). Our simulations are based on 1,000 random values for each input parameter. We create the inputs for each iteration by multiplying the standard error by randomly drawn number from a normal distribution with mean zero and standard error one and adding this product to each input's average for each iteration.

We favor cash balance and DC plans over DB pensions in our simulations. First, we exclude estimates that show a negative relationship between salary and effectiveness. Our average salary effect is instead the average of three positive effects and three zeros.[4] Second, we apply the estimates of the impact of salary on effectiveness to benefits, although employees value pension benefits less than salaries (Montgomery and Shaw, 1992). Third, we exclude transition costs associated with moving from DB pensions to alternative benefits, thus making more money available for compensation than would occur in reality. Fourth, we ignore the administrative costs of turnover, which can be substantive (Watlington et al., 2010), again making more money for compensation available. Fifth, we cut all turnover change estimates over 100% in half for cash balance plans, but leave them intact for DC plans. This will understate the potential risk to average teacher effectiveness in cash balance plans.

We calculate the chance of higher effectiveness with alternative benefits. Cash balance and DC plans lead to higher effectiveness if the average effectiveness after the switch exceeds 95.4% of the maximum effectiveness under a DB pension. We also calculate the average and 25th and 75th percentile of the effectiveness change relative to this threshold. This threshold results if we parameterize our model with the averages for experience, effectiveness, and turnover.

There is substantial risk of decreasing average effectiveness (Table 4). A change to cash balance plans may result in higher teacher effectiveness in only 41.2% of the cases and there is only a 30.2% chance that a switch to a DC plan will raise effectiveness. Average effectiveness decreases by 1.2% with a cash balance plan and by 4.3% with a DC plan. There is also a 25% chance that average effectiveness drops by 4.8% with a cash balance plan and by 9.4% with a switch to a DC plan (Table 4).

[4] Our results do not change materially if we reduce or increase the number of zero observations.

Table 4
Simulation results for teacher effectiveness changes, with alternative retirement benefits

	Probability of improvement relative to DB plan	Average change	Change at 25th percentile	Change at 75th percentile
Cash balance plan, follows DB plan	41.2	-1.2	-4.8	2.5
DC plan, follows DB plan	30.2	-4.3	-9.4	1.2
Cash balance plan, follows DB plan				
Low return to experience, fixed	100.0	2.3	1.8	2.9
High return to experience, fixed	0.0	-7.0	-7.7	-6.4
No change in turnover	87.4	2.5	1.0	4.0
No change in effectiveness	27.3	-3.2	-6.8	0.3
DC plan, follows DB plan				
Low return to experience, fixed	100.0	2.9	2.2	3.5
High return to experience, fixed	0.0	-11.3	-12.3	-10.2
No change in turnover	83.1	2.0	0.5	3.4
No change in effectiveness	24.8	-5.1	-10.0	0.01

Notes: All figures are in percent. Changes are relative changes.

The influence of experience, effectiveness, and turnover

Our input variables are turnover, the shape of the learning curve, and the response to initial compensation. How does the risk of lower teacher effectiveness change if we hold each input constant? We first hold the return to experience constant, either with a flat (low-return) or a steep (high-return) learning curve. The range of potential outcomes becomes much narrower (Table 3). A steeper learning curve reduces the average teacher effectiveness by 7.0% under a cash balance plan and by 11.3% under a DC plan, relative to a DB pension. The chance of improving teacher effectiveness increases with a comparatively flat learning curve, in comparison, and the average improvement increases to about 2%. The downside risk of a steeper learning curve exists because a state will have to hire more inexperienced teachers and the experience gap is larger than it would be with a flatter learning curve, thus reducing the average teacher effectiveness.

Next, we hold turnover constant, which substantially reduces the risk of decreasing teacher effectiveness. The chance of higher effectiveness increases to 87.4% for cash balance with an average improvement of 2.5% and to 83.1% for DC plans with an average improvement of 2.0%.

Holding average teacher effectiveness constant increases the risk of lower effectiveness. The chance of improving teacher effectiveness drops below 30% for cash balance plans and below 25% for DC plans. Effectiveness drops on average by 5.1% and 3.2%, respectively (Table 3).

Responding to a crisis

Policymakers may consider switching benefits, while cutting benefit costs. We calculate the effect of a 20% benefit cut coupled with a simultaneous benefit switch on effectiveness. Table 4 shows that the probability of improving effectiveness decreases by about five percentage points compared to a situation without benefit cuts (see Table 3). The average drops in effectiveness worsen to 2.0% from 1.2% for cash balance plans and to 4.6% from 4.3% for DC plans.

These results are expected. Turnover is the main determinant of the change in average effectiveness and we do not allow for additional increases in turnover due to the benefit cuts. Also, the initial compensation changes following retirement benefit switches are already small, before the cuts, because of phased vesting, such that the 20% cut has only a small additional adverse effect on the risk of lower average teacher effectiveness.

Policymakers may decide to improve their chances for improving effectiveness by shifting as much compensation to the early career years as possible, e.g. by having new hires become immediately vested. This raises the chance of improving average effectiveness, exceeding 60% in the case of cash balance plans with an average improvement of 2.1% (Table 4). There is still substantial risk of declining teacher effectiveness, particularly since our simulations already favor cash balance plans over DB pensions, e.g. we do not assume that turnover increases with immediate vesting, even though it eliminates economic incentives for younger teachers to stay.[5]

We alternatively allow for small increases in turnover in response to wealth losses, by assuming that a loss of $1,000 (in 1975 dollars) of retirement wealth leads to an increase in turnover by 1.2 percentage points with a standard deviation of 1.3 percentage points (Allen, Clark, & McDermed, 1993). This also lowers average teacher effectiveness under a DB plan to 91.7% of maximum effectiveness. Switching retirement benefits simultaneously with benefit cuts either adds little in the case of cash balance plans or leads to average effectiveness cuts beyond these reductions. The conversion to a cash balance plan, for instance, essentially keeps teacher effectiveness the same as with a DB pension, with a chance of 51.7% of improving effectiveness and an average improvement of 0.6% (Table 4). The chance of improving effectiveness falls to 40.9% for DC plans with an average decrease of 2.1%.

[5] Increasing the turnover change for cash balance plans in this case quickly drops the chance of improving average effectiveness below 50%.

Table 5
Simulation results for changes in teacher effectiveness, following changes in retirement plans and a 20% cut in retirement costs

	Probability of improvement relative to DB plan	Average change	Change at 25th percentile	Change at 75th percentile
No turnover change				
Cash balance plan	34.3	-2.0	-5.6	1.7
DC plan	26.6	-4.6	-9.3	0.5
No turnover change, immediate vesting				
Cash balance plan	63.4	2.1	-2.0	6.2
DC plan	44.5	-1.3	-6.8	3.9
Turnover change for all benefits after cut				
Cash balance plan	51.7	0.6	-4.7	5.6
DC plan	40.9	-2.1	-8.7	4.3

Calculating the transition costs from DB pensions to alternative benefits

A switch in retirement plans will likely come with transition costs. Promised benefits under the existing plan will have to be paid for until all existing beneficiaries are gone, while the start-up of a new plan will require higher up-front contributions due to the end of deferred compensation.

We present the transition costs for the next 10, 20, 30, and 40 years, and we calculate the average transition costs in each of the four decades following a switch in Table 5, assuming annual payroll will grow with inflation (2.5% per year) and labor force (1.0% per year). Transition costs initially increase as the concentration of more experienced teachers in the DB pension and of less experienced teachers in the cash balance plan grows. Transition costs start to decline in the third decade after the switch from a DB pension to an alternative retirement benefit.

Transition costs can be substantial.[6] They exceed on average one percent of payroll in the third transition decade, more than 10% of retirement costs. States and localities could spend this money to reduce their pension underfunding. Munnell, Aubry, and Quinby (2010) estimate that it would take 2% of payroll for thirty years to eliminate the shortfall in 2009, suggesting that the transition costs for the next thirty years could cover between 40% and 80% of the costs of the estimated underfunding.

[6] DC plan costs are lower than cash balance plan costs because turnover is greater and fewer teachers are vested.

Table 6
Transition costs for move from DB plan to cash balance plan or DC plan

	DB plan only (1)	Transition from DB plan to cash balance plan (2)	Transition from DB plan to DC plan (3)	Transition costs for cash balance plan (2)-(1)	Transition costs for DC plan (3)-(1)
Breakdown by time period					
10 years	10.25	10.6	9.7	0.4	-0.5
20 years	10.25	11.0	10.2	0.7	-0.1
30 years	10.25	11.2	10.6	0.9	0.3
40 years	10.25	10.9	10.6	0.7	0.3
Breakdown by decade					
First decade	10.25	10.6	9.7	0.4	-0.5
Second decade	10.25	11.2	10.5	1.0	0.2
Third decade	10.25	11.4	11.1	1.2	0.8
Fourth decade	10.25	10.5	10.6	0.2	0.3

Notes: All figures are in percent of payroll.

V. Policy implications and conclusion

The fiscal crisis in the states and localities that occurred after 2007 put substantial pressure on governments to consider the efficiency of their spending. Public pensions gained substantial attention due to the need for governments to contribute additional amounts, when budgets were already constrained. Some observers have argued that states should take the crisis as a chance to switch retirement benefits from DB pensions to either a DC or cash balance plan.

We evaluate the potential impact of changing retirement benefits on public employee effectiveness, specifically on average teacher effectiveness. Alternative benefits should increase employee turnover, which could reduce average effectiveness, if there is a learning curve. The decline could be offset by higher initial compensation since alternative retirement benefits no longer defer compensation into the future and thus possibly offer incentives for more effective employees to enter public service.

Each factor -- turnover, learning curve, and initial compensation -- that could influence average teacher effectiveness is fraught with uncertainty in the literature. We thus create a simulation model that incorporates this uncertainty by using a Monte Carlo simulation. We use this model to estimate the chance that teacher effectiveness will improve, based on a set of assumptions that are favorable to such an improvement. We find that there is only a 30.2% to 41.2% chance that average teacher effectiveness will increase after switching retirement benefits.

We analyze the role of each factor to determine its impact on the risk that teacher effectiveness will not improve and to inform future policy decisions. We find that keeping the increase in turnover is key, but it is difficult to keep turnover from rising without additional steps that would cost more money, such as bonuses and severance packages. An alternative may be to flatten the learning curve since it lowers the adverse effect of higher turnover on average teacher effectiveness. There are few proven tools available to flatten the learning curve and there is no evidence that an alternative retirement benefit will do so.

We further consider the change in average teacher effectiveness if we alter the policy scenario, specifically if we allow for benefit cuts simultaneously with a benefit switch. We conclude that a benefit cut further lowers the chance of increased teacher effectiveness.

Our results are a lower bound quantification of the risks involved in switching retirement benefits as defined by average teacher effectiveness since we choose input parameters for our simulations that favor alternative benefits over DB pensions. There would have to be substantial additional benefits from alternative benefits to overcome the substantial risk increases and our simulations suggest that the chance of additional benefits, e.g. higher teacher effectiveness, is below 50%, even under favorable assumptions.

The limited potential for additional benefits goes along with possibly substantial costs. We estimate that transition costs, for instance, can last about four decades, and that a switch to a cash balance plan requires transition costs of an average of 0.7% of payroll and a switch to DC plans 0.3% of payroll over the next 40 years.

These conclusions will likely hold for other public employees as well, although the literature is much better developed for teachers since they make up the largest share of public employees. There is no a priori reason to believe that simulations for other public employee groups that mirror teachers in key aspects, such as minimum skill levels and prolonged learning curves, would result in materially different outcomes. Our results -- based on a substantial literature related to pensions, teacher compensation, and teacher effectiveness -- suggest that states and localities face substantial risks with respect to public sector productivity when switching from DB pensions to alternative retirement benefits.

Technical Appendix

The discussions in the paper refer to a number of additional technical details that we present here in greater detail.

Setting the interest credit to the discount rate in a cash balance plan

The discount rate is a key variable in determining the level and pattern of contributions to a cash balance plan. It is not typical, though, that the interest credit is set equal to the discount rate. Employers typically set the interest credit lower to reduce the chance of underfunding in the pension plan. We believe, though, that a cash balance plan design with a comparatively low discount rate set equal to the interest credit is implied by two factors.

First, concerns with underfunding of teacher pension plans imply the use of a relatively low discount rate. The discount rates for teacher plans typically approach 7.5% instead of 7.0%. A lower interest rate translates into higher pension plan liabilities – the current value of future promised benefits. The discount rate is the assumed interest rate that employers hope to earn on the assets in their pension plans. A lower value means that interests, dividends, and capital gains are assumed to contribute a smaller share of future benefit payments than would be the case with higher interest rate assumptions. Employers would thus have to make larger contributions to their pension plans if they assume lower interest rates to fund the same amount of future promised benefits. A lower interest rate thus translates into higher contributions from the employers and employees to a pension plan. Higher annual contributions, though, lower the chance of underfunding since the pension plan relies less on financial market performance to pay benefits than would be the case with a higher assumed discount rate.

Second, those who propose the change from a DB plan to a cash balance plan, are explicitly concerned with the potential effects that deferred compensation may have on teacher turnover – more deferred compensation in the future should reduce teacher turnover (Costrell & Podgursky, 2009). The normal cost of a cash balance, however, would result in deferred compensation if the interest credit was lower than the discount rate. A lower interest credit would be associated with a larger pay credit. Employers can more easily meet the promised interest credit and can thus increase the pay credit. The normal cost – the change in retirement wealth – though is determined by the contribution to a retirement account plus the expected stream of interest payments on the contribution discounted back to the present. When the discount rate is greater than the interest credit, employers will have to contribute less than the pay credit to the notional account of an employee, especially in the early years of a teacher's career. The normal cost per employee would gradually increase relative to earnings with age, mirroring a pattern of deferred compensation. This is explicitly considered undesirable by those who propose a change from DB pensions to a cash balance plan for newly hired teachers (Costrell & Podgursky, 2009).

Range of parameters for optimistic and pessimistic scenarios

We assume a set of optimistic and pessimistic parameters for experience, salary effects, and turnover to show the range of possible outcomes. For the optimistic scenario, we assume a comparatively low return on experience. Teachers in their first year on the job are 8.5% less effective than experienced teachers and quickly become as effective as the most effective teacher

(Rivkin, Hanushek & Kain (2005). The pessimistic case assumes that it takes ten years before teachers reach their maximum effectiveness. The initial productivity is 35% below the maximum effectiveness and it takes ten years before teachers reach their maximum effectiveness (Harris & Sass, 2011).

Next, we show the range of initial salary effects. We assume a strong effect of compensation on effectiveness for the optimistic scenario. Hanushek, Rivkin, and Taylor (1996), for instance, find that a one percentage point gain in the ratio of initial teacher salaries to the average salary of college graduates increases student outcomes by 2.9%, although their estimates are not statistically significant. This means that average effectiveness of a first year teacher grows by 6.4% under a cash balance plan and by 5.8% under a DC plan, based on an initial compensation increase of 2.2% under a cash balance plan and a 2.0% increase under a DC plan.[7] The effectiveness in each year of a teacher's career will ultimately be higher by 6.4% and 5.8%, once an entire generation of teachers has entered the profession under a cash balance plan or a DC plan. In comparison, our pessimistic scenario assumes no improvement in teacher effectiveness after the switch to a cash balance or DC plan since most studies show no statistically significant relationship between teacher salary and teacher effectiveness (Hanushek & Rivkin, 2006).

Finally, we show the range of turnover assumptions. We assume a change in turnover of 22.0% for the cash balance plan, applied to the turnover rates of Harris and Adams (2007) at all ages, and an increase of 28% for the change to a DC plan for the optimistic case. We instead assume a high turnover increase for the pessimistic scenario. Even and MacPherson (1996) report the highest possible increase in the turnover rate as 220%. We assume that turnover increases by 220% in a switch to a DC plan and less, by only 110%, in a switch to a cash balance plan.

Monte Carlo simulation input parameters

Table A-1 summarizes the input parameters for our Monte Carlo simulation. The table shows the average and the standard error of each input parameter, based on selected available estimates. We select parameter estimates that are operationalizable for the simulation, e.g. we select changes in quit rates for turnover, but do not select differences in length of tenure. The resulting selections give us the largest possible range of parameters.

We bias our selection towards alternative benefits in the selection of parameters for the effect of initial compensation on teacher effectiveness. We specifically include statistically significant as well as insignificant estimates, but exclude negative coefficients. We give statistically insignificant values the value of zero and a weight of 50% in calculating the average and the standard deviation for the impact of initial compensation on teacher effectiveness. The elimination of negative values and assigning a weight of only 50% to statistically insignificant values overstates the effects of initial compensation on teacher effectiveness found in the literature (see Hanushek and Rivkin, 2006 for a summary of the available evidence).

We note three important points about our selection of parameter estimates for turnover. First, we select parameter estimates for changes in quit rates (and for the intention to quit for robustness

[7] We discuss only the change in initial pay that results from a changing retirement benefits. We do not model the possible effects of pay-for-performance schemes since they would not apply equally to all teachers.

reasons, as discussed below), instead of length of tenure, since we are interested in changes in turnover. The selection of coefficients used for our simulations represents a larger literature, as we note in the text, but many of the additional studies either include coefficient estimates that we cannot operationalize as changes in turnover or show similar findings as the ones we selected. Second, the majority of coefficient estimates for turnover in the literature compare workers with no retirement pension coverage with those with a DB pension or with a DC pension. Nyce (2007), though, provides an estimate of the intention to quit if benefits were changed. These estimates are similar to the ones that already exist in the literature. We thus feel confident that the selection of coefficient estimates indeed captures the difference in turnover rates under different retirement benefits. Third, few estimates exist for changes in turnover under cash balance plans, compared to DB pensions and DC plans, largely because cash balance plans have experienced substantial growth only in the past decade. Nyce (2007) offers some indication that turnover changes for cash balance plans are akin to DC plans. And, we make some ad hoc adjustment to the parameter calculation for turnover changes under cash balance plans by cutting turnover estimates above 100% into half for cash balance plans.

Our simulations are based on 1,000 random values for each input parameter. We create the inputs for each iteration by multiplying the standard error by randomly drawn number from a normal distribution with mean zero and standard error one and adding this product to each input's average for each iteration. This approach captures the random nature of future outcomes based on past experiences with respect to initial compensation, turnover, and experience.

Table A-1
Input parameters for simulation

Measure	Range of estimates	Parameter average and standard deviation	Sources
Change in teacher effectiveness relative to 1% change in initial salary	0.0 to 2.9	0.89 (1.26)	Cohn (1968), Rivkin, Hanushek, & Kain (2005), Hanushek and Rivkin (2006), and Perl (1973)[a, b]
Change in turnover relative to DB plan			Allen, Clark, &McDermed (1993), Even and MacPherson (1996), Ippolito (1997), and Nyce (2008)
• **For cash balance plans**	22.0 to 110.0	52.9 (28.9)	
• **For DC plans**	28.0 to 220.0	93.8 (70.5)	
Experience – teacher effectiveness level in years 1-10 relative to maximum effectiveness			Harris and Sass (2011), Rivkin, Hanushek, & Kain (2005)
• **Year 1**	-35.0 to -8.5	21.8 (18.7)	
• **Year 2**	-34.0 to -4.3	19.2 (21.0)	
• **Year 3**	-32.0 to -1.8	16.9 (21.4)	
• **Year 4**	-29.0 to -1.2	15.1 (19.7)	
• **Year 5**	-25.0 to -1.2	13.1 (16.8)	
• **Year 6**	-20.0 to 0.0	10.0 (14.1)	
• **Year 7**	-15.0 to 0.0	7.5 (10.6)	
• **Year 8**	-10.0 to 0.0	5.0 (7.1)	
• **Year 9**	-5.0 to 0.0	2.5 (3.5)	
• **Year 10**	-2.0 to 0.0	1.0 (1.4)	

Notes: All numbers are in percent. [a] We treat the parameter estimate from Rivkin, Hanushek, & Kain (2005) as statistically significant, even though it is insignificant, since it gives us the largest possible positive response in teacher effectiveness to initial compensation changes. This again biases our estimates in favor of alternative retirement benefits. [b] The calculation of the average and standard deviation for the parameter of initial compensation also includes statistically insignificant values, which we assign the value zero and give a weight of 50% in the calculation of the average and standard deviation.

Impact on teacher effectiveness: optimistic and pessimistic scenario

We next show an optimistic and a pessimistic scenario to show the range of realistic outcomes, based on input parameters detailed in Table A-1. Table A-2 presents both scenarios. Average teacher effectiveness increases by 5.8% after switching from a DB plan to a cash balance plan and by 5.0% after a switch to a DC plan in the optimistic case. And, average teacher effectiveness drops by 11.1% under a cash balance plan and by 17.5% under a DC plan, following a switch from a DB plan, in the pessimistic case (Table A-2).

Our optimistic scenario shows that there may be some opportunity to improve teacher effectiveness by switching teacher retirement benefits. The average increase ranges from 5.8% for DC plans to 5.0% for a cash balance plan, which translates into annual rates of change of teacher effectiveness of 0.2% in addition to regularly occurring productive increases.

The downside risk, on the other hand, may be larger than the upside potential. The average effectiveness could drop by as much as 17.5% with DC plans and by 11.1% with cash balance plans, equaling annual decreases between -0.3% and -0.5%, or more than twice as much as the potential annual improvement.

Table A-2

Optimistic and pessimistic scenarios of the impact of retirement benefit changes on average teacher effectiveness

	DB plan	Cash balance plan	DC plan
Optimistic scenario			
Effect of experience	1.2%-8.5% reduction in first five years	1.2%-8.5% reduction in first five years	1.2%-8.5% reduction in first five years
Change in effectiveness of new teachers, after replacing DB plan		9.2%	8.4%
Change in turnover, after replacing DB plan		22.0%	28.0%
Average teacher effectiveness (as share of average maximum teacher effectiveness)	98.8%	104.5%	103.7%
Total change in teacher effectiveness, relative to DB plan		5.8%	5.0%
Annual change in teacher effectiveness, relative to DB plan		0.1%	0.1%
Pessimistic scenario			
Effect of inexperience	2%-35% in first ten years		
Change in effectiveness of new teachers, after replacing DB plan		0%	0%
Change in turnover, after replacing DB plan		110%	220%
Average teacher effectiveness (as share of average maximum teacher effectiveness)	92.0%	81.8%	76.0%
Total change in teacher effectiveness, relative to DB plan		-11.1%	-17.5%

Annual change in teacher effectiveness, relative to DB plan	-0.3%	-0.5%

Notes: See discussion in text for pension plan characteristics and determination of parameters.

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