Working Paper

Exploring Voluntary Retirement Incentives for Teachers

Effects on Retention and Cost in Chicago Public Schools

David Knapp, James Hosek, Michael G. Mattock, Beth J. Asch

RAND Education

WR-1249
May 2018

RAND CORPORATION

For more information on this publication, visit www.rand.org/pubs/working_papers/WR1249.html

Published by the RAND Corporation, Santa Monica, Calif.

Abstract

Many school districts have used or are considering the use of voluntary retirement incentives. The intent of these incentives is to decrease the payroll cost of their workforce, decrease retirement fund liability, decrease workforce size without layoffs, or a combination of these outcomes. At the end of the 2017 school year, Chicago Public Schools offered a one-time, unanticipated retirement incentive for the purpose of reducing its cost by shifting from the employment of retirement-eligible to new teachers; the latter group is paid 70 percent of the senior teacher's salary. It offered $1,500 per year of service of non-pensionable income for teachers who agreed to retire immediately. We use a dynamic model of teacher retention behavior to predict the number of teachers willing to accept this voluntary retirement incentive and retire. The model is estimated using individual-level data on entry cohorts of Chicago teachers from 1979-2000, which are the cohorts affected by the retirement incentive. Our model predicts that only 588 of the 2,700 teachers eligible for the benefit will retire. Our research reveals two important dimensions to consider in retirement incentive design. First, a voluntary retirement incentive results in substantial economic rents: payments to individuals who would have retired without the incentive. For Chicago's incentive, this would amount to 73% of payments. Second, if the incentive appeals to individuals closest to indifference between continuing to teach and retiring, those who are incentivized to retire would have likely retired within a few years without the incentive. In the case of Chicago, if they replace all teachers that are incentivized to retire, we find negative cost savings over the next six years. If not all retiring teachers are replaced, the cost savings could be positive.

Table of Contents

Figures

Tables

Summary

Many state and local public pension programs, including those for public school teachers, are underfunded. The underfunding generally cannot be eliminated by actions to decrease the retirement benefit of vested employees as law prohibits this. In some cases, the response has been to decrease the generosity of pensions for newly hired employees. While this will lower pension fund contributions and pension liabilities for these employees, it does little to address the unfunded pension liability of existing employees. Another approach focuses on decreasing the cost of the teacher workforce, potentially freeing up resources to allocate to the retirement fund to reduce underfunding.

During contract negotiations in 2016 between the Chicago Public Schools (CPS) and the teacher's union agreed to a one-time retirement incentive for senior teachers eligible for retirement. The district's expectation was that retiring teachers would be replaced with new hires. Senior teachers are paid approximately 70% more than junior teachers, and senior teachers fall under a more expensive pension plan than new teachers. The union and the district expected that a retirement incentive would encourage voluntary separations and reduce operating expenses by trading senior for junior teachers.

In this research, we predict the take-up of this incentive using a dynamic model of CPS teacher retention behavior for teachers that start their career in Chicago. The model accounts for current and deferred compensation for teaching versus not teachers, as well as permanent unobserved differences in a teacher's taste for teaching in CPS over the next best alternative. The model is estimated on entry cohorts of CPS teachers from 1979-2000, which are the cohorts affected by the retirement incentive.

We predict that for the retirement incentive of $1,500 per year of service agreed to in the teachers contract, approximately 588 of 2,700 eligible teachers will retire. Of the teachers retiring, 73% would have retired without the incentive. Since Chicago cannot distinguish teachers that retire because of the incentive, the payment is made to all teachers retiring at the end of the 2016-17 school year, resulting in economic rents. In addition, the model predicts that teachers predicted to retire would have likely retired soon without it, effectively diminishing the costs avoided by trading senior for junior teachers. The predicted net savings from offering the incentive depends on how many retiring teachers are replaced. If all retiring teachers are replaced, cost savings are negative over the next six years. If the retiring teachers are not replaced, cost savings are positive. In both cases, the net savings or loss is small relative to the district's operating budget.

This research has implications for optimal incentive design and efforts to cope with unfunded pension liabilities. Retirement incentives are frequently used in the public sector to encourage voluntary separation in lieu of involuntary separation. The incentive design in Chicago does not

appear to encourage separation substantially earlier than what individuals would have done without an incentive. Alternative approaches, such as combining a retirement incentive with pension enhancement (e.g., no reduction in benefit payments for early retirement claiming) or offering a separation incentive to a particular subset of near-retirement teachers, could create stronger incentives for teachers to retire at an earlier point in their career, likely creating larger short-run cost savings although the long-run budgetary impact is uncertain.

Acknowledgements

Funding for this study was provided by philanthropic contributions from RAND supporters and income from operations. We thank RAND Education, especially Darleen Opfer, Director of RAND Education, for her support and encouragement during the many stages of this work.

Abbreviations

CPS	Chicago Public Schools
CTPF	Chicago Teachers Pension Fund
CTU	Chicago Teachers Union
FY	Fiscal Year
ISBE	Illinois State Board of Education

1. Introduction

Many state and local public pension programs, including those for public school teachers, are underfunded. The Chicago Teachers Pension Fund (CTPF) is no exception, and its pace of decline into underfunding was dramatic. CTPF was more than 90 percent funded from fiscal 1995 through 2003, and over 100 percent funded in 1997 and 1998. But with low contributions and optimistic assumptions of return on assets, CTPF had become less than 70 percent funded in fiscal year (FY) 2010 and further declined to 49 percent in FY2013, i.e., its assets covered only half of its total accrued actuarial liability (Chicago Public Schools, 2016).[1]

In response to this worsening situation, the State of Illinois enacted Public Act 96-0889 in April 2010. It required the Chicago Board of Education to make larger-than-usual annual contributions to CTPF beginning in FY2014 to achieve 90 percent funding by the end of FY2059. The impact was profound. Employer contributions to CTPF, which stood at $143 million in FY2013, jumped to $585 million in FY2014, $644 million in FY2015, and $635 million in FY2016 (Segal Consulting, 2016) The Board of Education looked to the state for fiscal relief, arguing that it was being treated unfairly. For instance, the state contributed $3.7 billion in FY2016 to the Illinois Teacher Retirement System, which covers non-Chicago public school teachers, but only $12 million to CTPF. Legislation under consideration in FY2017 would have increased the state contribution to CTPF to $215 million in FY2017, and Chicago Public Schools (CPS) counted on these funds when constructing its FY2017 budget (Kilroy, 2016b). However, the governor vetoed the bill and called for more comprehensive pension reform (Kilroy, 2016a, 2016b). The Illinois Senate overrode the governor's veto, but the House adjourned without a final vote on the bill. The matter came up again when the legislature reconvened, and in August 2017 Senate Bill 1947 passed both the House and Senate and was signed by the governor, becoming Public Act (P.A.) 100-0465. Under this legislation, the State will pay the normal cost percentage of CTPF beginning in the current fiscal year (July 1, 2017 to June 30, 2018).[2] The legislation further provides that beginning in the 2017 tax year Chicago's Board of Education may impose a property tax levy of up to 0.567 percent, up from the current cap on the levy of 0.383 percent. Any increased funding from the levy is earmarked for CTPF. The State will now pay the normal cost of teacher pensions throughout the state, whereas previously Chicago had

[1] Fiscal years for CTPF are from July-June, e.g., FY2016 covers July 2015-June 2016

[2] The normal cost the State will pay to CTPF was estimated to be $221 million, and the increase in property taxes was estimated to raise $125 million (Chicago Teachers' Pension Fund, 2017); Of greater importance from the perspective of school reform, SB 1947 mandates an evidence-based model for school funding (Ahern and Bremer, 2017). This "breakthrough legislation…ties the dollar amount taxpayers invest in schools to those educational practices which the research shows actually enhance student achievement over time;" (Martire, Otter, Hertz, 2017).

paid it. While the increased tax levy will enable CPS to contribute more to CTPF, CPS is still liable to pay the unfunded liability of the CTPF (Martire et al. 2017)

In the climate of fiscal pressure and uncertainty prevailing before the passage of P.A. 100-0465 (and still continuing), CPS sought budget savings.[3] The contract negotiations that were underway between CPS and the Chicago Teachers Union (CTU) in 2016 led to an agreement on a one-time retirement incentive for senior teachers eligible for retirement. The district's expectation was that retiring teachers would be replaced with new hires. Senior teachers are paid approximately 70 percent more than junior teachers, and senior teachers are covered by a more expensive pension plan than new teachers. The union and the district expected that a retirement incentive would encourage the voluntary separation of retirement-eligible teachers and enable CPS to reduce operating expenses by trading senior for junior teachers.

In this research, we extend a dynamic model of teacher retention behavior, previously estimated in Knapp, Brown, Hosek, Mattock, and Asch (2016), to predict the number of teachers willing to accept a voluntary retirement incentive and retire. The model is estimated on CPS teacher data for teachers that start their career in Chicago and accounts for current and deferred compensation as well as permanent unobserved differences in a teacher's net preference, or taste, for teaching in CPS over the next best alternative. We estimate the model with individual-level data on entry cohorts of CPS teachers from 1979-2000, which are the cohorts affected by the retirement incentive. The model is extended to incorporate policy transitions and the costs. Prior to 2016 and after 2017 teachers made their retirement decisions without a retirement incentive, but in 2017 they were offered an incentive to retire. Teacher response to this policy innovation depend on years of service and age, among other factors, which implies a unique policy response for each age and years of service combination. Costs of policy changes are determined by the characteristics of specific teachers that are retiring (e.g., salary depends on years of service).

We use the estimated model in two ways. The first concerns the design of the retirement incentive and its generosity in particular. We consider the take-up response over a range of incentive payment rates per year of teaching service, and we consider both the immediate decrease in teacher retention among takers and the retention profile of remaining teachers, those choosing not to take the incentive. The range includes the rate of $1,500 per year of service agreed to in the CPS-CTU contract negotiations. We compute the cost of the incentive, the hiring of new teachers needed to replace the takers to maintain the overall teacher workforce, and the year-by-year budget cost decrease or increase resulting from the incentive and replacement hiring.

Second, we consider the same elements but from the perspective of achieving a given target level of takers. The target is beyond the number of takers predicted by the incentive alone and

[3] The failure to pass the pension legislation in January 2017 meant that CPS would not receive $215 million from the State that it had included in its budget in anticipation of reform (Chicago Public Schools, 2017). This forced CPS to implement a mid-year freeze on spending and furlough teachers, which generated cost savings of $104 million.

can be thought of as resulting from an action outside of the behavioral model, such as an outreach campaign to inform and persuade teachers to take the incentive. The presumption is that this action is effective in reaching the target, and we compute the retention, replacement hiring, incentive cost, and year-by-year cost decrease or increase, as before. The underlying question is, which teachers take the incentive. Cost savings are greater if teachers who would have taught for many more years tend to take the incentive, as compared with teachers who would have taught only another year or two. We consider two selection mechanisms: teachers who would voluntarily take the given incentive plus a random sample of the remaining teachers eligible for the incentive, and teachers who would have taken an hypothetical incentive large enough to generate the target number of takers. We believe that the results from these two mechanisms lie in a plausible range of response to an action to induce teachers to take the incentive, although the actual response will depend on the specifics of the action.

Among our findings, we predict that the retirement incentive of $1,500 per year of service, which was agreed to contract negotiations between CPS and CTU, will have approximately 588 takers out of 2,700 eligible teachers. Of the teachers retiring, 73 percent would have retired without the incentive. Because teachers that retire because of the incentive cannot be distinguished from teachers who would have retired anyway, the payment is made to all teachers retiring, resulting in economic rents. In addition, the model predicts that teachers electing to retire when the incentive is offered would have likely retired soon afterwards without it, leading to a relatively small decrease in salary cost. For the same reason, the cost avoided by trading senior for junior teachers is relatively small. However, the predicted net savings from the incentive depends on how many retiring teachers are replaced. If all retiring teachers are replaced, total cost savings over the next six years are negative. If the retiring teachers are not replaced, cost savings are positive. In both cases, the net decrease or increase in cost is small relative to the district's operating budget.

We also find that an action taken to achieve a target number of retirees would result in a budget cost decrease even though every retiree would be paid the monetary retirement incentive. Yet this result depends on the assumption that the action itself imposes no additional budget cost, e.g., it is done within the existing budget for administration and operations. Any additional cost imposed by the action would decrease budget savings.

This research has implications for optimal incentive design and efforts to cope with unfunded pension liabilities. Retirement incentives are frequently used in the public sector to encourage voluntary separation in lieu of involuntary separation. The incentive design in Chicago does not appear to encourage separation substantially earlier than what individuals would have done without an incentive. Alternative approaches, such as combining a retirement incentive with pension enhancement (e.g., no reduction in benefit payments for early retirement claiming) or offering a separation incentive to a particular subset of near-retirement teachers, could create stronger incentives for teachers to retire at an earlier point in their career, likely creating larger short-run cost savings although the long-run budgetary impact is uncertain.

Chapter 2 will discuss voluntary retirement incentives and provide background on CPS compensation. Chapter 3 will discuss the dynamic retention model that we have previously estimated on teacher retention data and use for the policy simulations. This chapter also discusses new extensions of the model to incorporate policy transitions and compute policy costs during a transition. Chapter 4 reviews the data and assumptions used in estimating the model, and reviews the model's parameter estimates and fit. In chapter 5, the model is applied to voluntary retirement incentives to produce results on retention and cost, as described above. Chapter 6, the conclusion, discusses insights from the findings for retirement incentives and possible future research.

2. Background on CPS Salary Schedule, Pensions, and Voluntary Retirement Incentive

In this section we provide background on CPS compensation and discuss the voluntary retirement incentive offered during the 2016-2017 school year.

CPS Teacher Salary Schedule

We use information on teacher salaries from the 2015 – 2016 CPS salary schedule for 208-day employees for the typical school year to provide background information on the structure of salaries by education, age, and years of service.[4]

Teacher salaries increase with education. The beginning salary was $50,653 for a teacher with a bachelor degree, $54,161 for a teacher with a master's degree, $55,916 for a teacher with 15 hours of additional study beyond a master's degree, $57,670 for a teacher with 30 hours of additional study beyond a master's degree, and $59,424 for a teacher with 45 hours of additional study beyond a master's degree. The top end of the scales, "step 16," showed salaries of $85,920, $89,534, $91,339, $93,146, and $94,952, respectively. Teachers that begin with a bachelor's degree often obtain a master's degree within a few years, and those with a master's often do additional hours of study beyond the master's.

Table 2.1 shows average salary by age and years of service for CPS teachers as of September 2016. The table is computed to show average salary as based on the CPS salary schedule, prior to pension contributions. Each participant is required to contribute 9 percent of salary to the pension fund, however CPS "picks up" 7 percent of this. As a result, the effective salary is 7 percent higher than the amount shown in the table.[5] The average salary over a career in CPS can be illustrated by the entries along the diagonal, shown in bold, starting with ages 25-29 and years of service 1-4. This salary is $52,157. At ages 30-34 and 5-9 years of service the salary is $63,797, and ages 45-49 and 20-24 years of service the salary is $86,899. For teachers with 20 or more years of service and at ages 55 and up, the average salary is roughly in the $85,000 to $95,000 range. Adding in the 7 percent pick-up, this range is $91,000 to $102,000. With respect to the potential budget impact from retiring a teacher with 30-34 years of service and hiring a replacement at the front end, CPS salary cost in the first few years after the change would be about $40,000 per year lower.

A second feature of the table is the close correspondence between the entries along the diagonal, just described, and the entries at the bottom of the column, which show the average

[4] The agreement reached between CPS and CTU had no cost-of-living adjustments for the 2016-2017 school year.

[5] For a scheduled salary of x, the required CTPF contribution is .09x and the salary plus pick-up is x + .07x.

salary for each year of service group. In any year of service group there are teachers of various ages, yet to a near approximation the average salary for a teacher on the diagonal is typical of the average salary for all teachers in that years of service group. This underscores the idea that swapping a high years-of-service teacher for a replacement teacher beginning at the bottom of years-of-service rung would generate salary savings of about $40,000 per year in the first few years—regardless of the age of the replacement teacher. However, if the replacement had taught elsewhere and could transfer prior years of service to CPS under a reciprocity agreement, the beginning salary would be higher and the budget savings lower.

Table 2.1. Average Salary by Age and Years of Service for Chicago Teachers Pension Fund as of September 2016

	Years of Service										
Age	<1	1-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40+	Average
Under 25	**50,416**	49,912	50,653								50,156
25-29	52,275	**52,158**	56,259	53,858							52,877
30-34	52,541	54,627	**63,797**	73,278	61,090		64,252				61,595
35-39	54,232	54,931	66,399	**77,786**	82,088		70,137				71,815
40-44	54,604	55,425	66,931	79,019	**83,211**	85,487	69,441				77,683
45-49	52,853	55,377	67,044	78,909	84,729	**86,899**	85,685	45,942			81,059
50-54	53,992	56,664	67,130	80,308	84,820	87,142	**87,470**	85,957			82,959
55-59	48,851	56,472	67,724	81,161	84,910	87,038	88,080	**89,991**	90,590		84,234
60-64	55,342	57,059	71,092	79,525	86,105	87,696	88,086	89,643	**89,901**	90,451	84,785
65-69	54,853	59,826	68,677	83,746	88,278	87,594	88,515	89,040	93,020	**88,901**	86,042
70 & over			80,665	86,538	86,364	91,920	90,886	87,727	94,952	92,630	**89,742**
Average	52,028	53,409	64,410	78,180	84,065	86,948	87,393	89,037	90,784	89,764	72,318

Source: Author's calculation from CPS provided teacher data. Data is restricted to teachers and principals.

CPS Pensions

Chicago teachers and administrators are covered by CTPF, which is a defined benefit pension system. We refer to both teachers and administrators as "teachers" for short. CPS opted out of Social Security, and CTPF is the sole source of pension benefits accumulated through CPS employment. CTPF offers retiree health insurance and teachers have participated in Medicare since 1986.

Chicago teachers in our period of study are covered by the CTPF Tier 1[6] retirement plan. This defined benefit pension plan has the features typical of most teachers' pensions in the U.S. (Hansen, 2010) and has similarities with the defined benefit plans of government employees and

[6] Teachers hired on or after January 1, 2011 are in Tier 2 of the CTPF.

military personnel. The details of the retirement plan for the period under study are described below and summarized in Table 2.2.

Table 2.2. Overview of CTPF Pensions

	Tier 1 (Hired before January 1, 2011)		Tier 2 (Hired on/after January 1, 2011)
	Service earned before 7/1/1998	Service earned after 7/1/1998	
Employee contribution rate	8% of salary each year	9% of salary	9% of salary
Paid by employee	1% of salary each year	2% of salary each year	2% of salary each year
Paid by employer	7% of salary each year	7% of salary each year	7% of salary each year
Vesting service requirement	5 years		10 years
Benefit Multiplier	1.67% for years of service 1-10 1.90% for years of service 11-20 2.10% for years of service 21-30 2.30% for years of service 31+	2.20% for all years of service	2.20% for all years of service
Max. Retirement Benefit	75% of Final Average Salary		75% of Final Average Salary
Normal Retirement Age	Age 55 with 33.95 or more years of service, or Age 60 with at least 20 years of service, or Age 62 with at least 5 years of service		67 with at least 10 years of service
Early Retirement Age	Age 55 with at least 20 years of service		62 with at least 10 years of service
Early Retirement Benefit Reduction	Benefit is reduced by 6% for each year below age 60 or 33.95 years of service		Benefit is reduced by 6% for each year below age 67
Final Average Salary	Average of salary for 4 highest consecutive earnings years, of most recent 10 years of service		Average of salary for 8 highest consecutive earnings years, of most recent 10 years of service
Pensionable Earnings Cap	None		Yes ($111,571.63 in 2015)
Cost of Living Adjustment	3% compounded annually beginning at the later of 1 year after retirement or age 61		Lesser of 3% or one-half of CPI, calculated on initial pension amount
Spouse Survivor Benefit	50% of retirement benefit		66 2/3 % of retirement benefit (or earned annuity)

As mentioned, participants must contribute 9 percent of their salary to CTPF, and CPS contributed 7 percent of salary on behalf of teachers during the time period we study, leaving 2 percent to be paid directly from the participant's salary. Teachers vest in CTPF Tier 1 after five years of service in CPS.

The CTPF normal retirement age increases as years of service decrease. The normal retirement age is 55 for a teacher with 33.95 years of service, age 60 for a teacher with 20 years of service, and age 62 for a vested teacher with fewer than 20 years of service. At the normal retirement age, teachers are eligible to receive the full retirement benefit.

The full benefit is calculated as $B = M \times YOS \times FAS$, where M is the pension multiplier, YOS is the total number of covered years of service in CPS, and FAS is the teacher's final average salary. The pension multiplier was incremented by years of service before 1998 and has been 2.2 percent per year of CPS service since then. Together, the multiplier and years of service determine the fraction of the final average salary that is received as a retirement benefit. For example, with a 2.2 percent multiplier and 20 years of service, a teacher who has reached the normal retirement age of 60 would receive a retirement benefit equal to 44 percent (20 × 2.2 percent) of his or her final average salary. CTPF calculates the final average salary for Tier 1 teachers as the average of the four highest consecutive years of earnings within the most recent 10 years of service. This is the last four years of earnings for most teachers.

The final average salary is nominal, i.e., it is not adjusted for inflation or subsequent increases in the CPS salary schedule. For teachers retiring at the end of their work life, final average salary is likely only a few percentage points less than if the salary were adjusted for inflation to bring it to current-year dollars. However, the lack of an inflation adjustment can make a large difference to a teacher who leaves CPS after 10 years of service at age 35 and claims CPS retirement benefits at age 62. At an average inflation rate of 2 percent per year, each dollar of final average salary at age 35 has an inflation-adjusted value at age 62 of $0.58, a 42 percent decrease in value.

A teacher with at least 20 years of service may retire early between the ages of 55 and 60 but the retirement benefit is reduced by 6 percent for each year short of normal retirement age. A teacher with, say, 30.95 years of service can retire at age 57 instead of age 60 but with 18 percent less, or .82 of the normal-age benefit. Because the normal retirement age changes based on years of service, a 57-year old teacher with 31.95 years of service would have her benefit reduced by only 12 percent given that she would be eligible for a full pension with only two more years of service, bringing total years of service to 33.95.

Teachers can increase their retirement benefits through the purchase of creditable years of service. Unused sick leave can be converted to service credits. The amount that can be converted is currently capped at 244 days, which is equivalent to 1.4 years of service. Teachers can also buy creditable service for time spent on approved leave, e.g., maternity/paternity leave. The current maximum allowed for unpaid approved leaves of absence is 36 months.

Once begun, retirement benefits are adjusted for inflation. The annual cost of living adjustment for CTPF Tier 1 teachers is 3 percent. The COLA starts one year after retirement, or at age 61, whichever is later, and the COLAs are compounded.[7]

Summarizing, Tier 1 teachers vest after five years of service, may receive full benefits at age 55 with 33.95 years of service, or at age 60 with 20 years of service, or at age 62 with less than 20 years of service. Early retirement is possible with some benefit reduction. Benefit amount is determined by a typical defined-benefit formula, $B = M \times YOS \times FAS$, and final average salary is in nominal terms as of the years it was earned. Retirement benefits have an annual COLA of 3%.

CPS Voluntary Retirement Incentive

The CPS voluntary retirement incentive (VRI) pays a lump sum amount equal to the VRI rate multiplied by years of service in CPS. CPS negotiations with CTU settled on a VRI rate of $1,500 per year of service in CPS. Additionally, 1,500 teachers must agree to retire by March 31, 2017 in order for the VRI to be paid. The VRI is available to teachers eligible to retire at the end of FY2017, which is June 30, 2017. Accepting the incentive is voluntary, and it does not affect the teacher's pension amount. However, because the pension amount depends on years of service, a teacher induced to retire by the incentive would have fewer years of service, hence a lower pension, than otherwise, i.e., continuing to work until retirement would have occurred. Still, the pension would be received for more years. Similarly, for teachers who can retire early, the decrement to the pension might be greater if retirement were sooner than otherwise expected. As mentioned, CPS may hire teachers to replace the retiring teachers. Hiring would help to maintain the teacher workforce and prevent increases in class size.

The reported objective of the VRI is to decrease CPS budget costs. However, teachers willing to accept VRI may rescind their acceptance if the total number of teachers does not reach the target of 1,500 retirees agreed upon by CPS and CTU. Finally, VRI was a one-time offer. There was no plan to offer a voluntary retirement incentive in future years. Although the VRI rate was set at $1,500, we explore a range of VRI rates to identify how the retention responses and cost savings vary.

[7] A provision in the omnibus bill pending in Illinois would require workers to choose between having future salary increases count in computing final average salary but foregoing the 3 percent COLA, or not having the salary increases count but retaining the 3 percent COLA (McKinney & Pierog, 2017)

3. Dynamic Retention Model for CPS Teachers

In this research, we extend a dynamic model of teacher retention behavior, estimated in Knapp et al. (2016), to predict the number of teachers willing to accept a voluntary retirement incentive and retire. This section provides an overview of the model and then gives a more formal presentation of the model from Knapp et al. (2016). Readers less interested in the technical details might skip this more formal discussion. We conclude with a discussion of how the model is extended to incorporate policy transitions and the costs that are necessary to simulate teacher retention from a one-time voluntary retirement incentive and provide estimates for the personnel cost savings from the incentive.

Model Overview

The DRM is an estimable theoretical model of an individual's retention decision making over a career with a given employer. Individuals are assumed to be rational and forward-looking, taking into account expected future earnings from the employer, their own preference for employment with that employer, and uncertainty about future events that could cause them to value their current service more or less, relative to their external opportunities.[8] The estimated model can be used to simulate the retention profile of an entry cohort of CPS teachers under the employer's existing compensation policy (baseline retention), as well as the retention profile under alternative compensation policies, such as changes to the retirement system. The simulations can reveal the effect of those policies on the size of the workforce that is retained and the required number of additional hires needed to sustain the workforce should it decrease. While we do not explicitly model hiring, the effect of the policy on the required number of hires is completely determined by the change in retention.

In the DRM for CPS teachers, the value of staying depends on teacher expected earnings in each year of CPS service and the teacher's "taste" for teaching in CPS relative to the external market. Taste includes the monetary equivalent of the intangible preference for teaching in CPS relative to the external market, and any persistent difference between the individual's own expected earnings and valuation of job conditions in CPS versus those in an external position. This might include an interest in reaching children during their formative years, positive and negative aspects the individual perceives about teaching in CPS, e.g., hours of work, paid leave, an annual schedule centered on the academic calendar), and persistent differences in CPS teacher and private-sector earnings apart from the differences accounted for in the model. The model

[8] The DRM was originally extended to CPS teachers and estimated in Knapp et al. (2016). The present paper further extends the policy simulation capability of the DRM for CPS teachers to evaluate the impact of a one-time retirement incentive.

uses a single curve to represent teacher salary and external salary by age. But an individual might believe his or her teacher and external salaries are persistently higher or lower than those curves. The net effect of these perceived differences enter into taste. Another way of describing taste, then, is as a person-specific fixed effect. Although taste is unobserved, we assume it has a normal distribution among teachers entering teaching at the beginning of their work career and we estimate the mean and standard deviation of the taste distribution. The value of staying also depends on a period- and individual-specific environmental disturbance term, or shock, that can positively or negatively affect the value placed on teaching in that period. For example, having an ailing family member who requires assistance with home care could be such a shock.

In additional to expected earnings, person-specific taste, and person-specific shock, the value of staying as a CPS teacher includes the value of the option to leave at a later date. This value comes from being able to revisit and re-optimize the decision to stay or leave in each future period. The future is uncertain and the shocks that will be realized in future periods are not known in the current period, but there is value in having the opportunity to choose between staying and leaving in each future period as compared to committing in the current period to a certain length of stay, or certain time of departure, in the future. Like taste, the shock is unobserved but we assume shocks follow a particular distribution, extreme value with zero mean, and we estimate the standard deviation of the distribution.

Choices made in the current period affect the value of choices in the future. A teacher who chooses to stay in CPS adds a year of service, moving closer to retirement eligibility and increasing retirement benefits, thereby influencing the value of choosing teaching in CPS in the future. For the same reason, past choices affect the value of staying at CPS in the current period.

The value of leaving includes expected earnings in the external market (or the forgone value of pay if the individual decides not to stay in the labor market), plus any CPS retirement benefits the individual is entitled to receive.[9] Some individuals who leave CPS might leave the labor force, and although we do not know the value of their "home" time we use the value of foregone external pay to represent it. The value of leaving does not include a term representing preference for external work, non-pecuniary factors, or person-specific differences between the individual's own expected wage and the representative expected wage, because these factors are subsumed in the taste for staying. The value of leaving also includes an individual- and period-specific shock,

---

[9] We also considered including the potential Social Security benefit, but we chose to omit it in the final analysis. Since CPS does not contribute to Social Security, a teacher would have to leave by a certain age in order to accumulate the minimal ten years of Social Security contributions in order to qualify for these benefits. In addition, these benefits are reduced due to the Government Pension Offset, a special rule applied to public sector workers, like those in CPS, who do not contribute to Social Security while working in the public sector. When we included Social Security in the model, we assumed that individuals completely internalized the structure of these benefits. However, it was clear during the model's estimation that either these benefits are not valued at the same level as other compensation or teachers did not fully internalize the structure of Social Security, because the inclusion of it substantially reduced the fit of the model by inducing simulated behaviors at odds with those observed in the data. Omitting Social Security from the model assumes that teacher's do not internalize the structure of Social Security in making their decision of whether or not to stay in CPS.

and it can be positive or negative. Pay in the external market varies with age, with those entering CPS at older ages having higher external pay opportunities. Entry age can also affect how soon CPS retirement benefits are available to an entering individual.

An individual who leaves CPS might remain in teaching, obtain work in a different occupation, work full- or part-time, or leave the labor force. We use the earnings of full-time workers, excluding teachers, in the Chicago metropolitan area to represent external earnings.

Formal Model

More formally, the value of staying to teach in CPS for a teacher of age *a* at time *t* is $V_{a,t}^{S} + \varepsilon_t^c$, where $V_{a,t}^{S}$ represents the expected value of staying and ε_t^c is the random shock to CPS teacher employment at time *t*. The expected value of staying is

$$V_{a,t}^{S} = \gamma^c + w_t^c + \beta E_t\left[Max\left(V_{a+1,t+1}^{S} + \varepsilon_{t+1}^{c}, V_{a+1,t+1}^{L} + \varepsilon_{t+1}^{e}\right)\right] \quad (3.1)$$

where

γ^c is individual taste for CPS teaching relative to an external position

w_t^c is CPS teacher average annual earnings at time *t* (and experience in CPS is also *t*)

β is the personal discount factor

$V_{a+1,t+1}^{S}$ is the value of staying as a teacher in CPS at age *a* + 1 and time *t* + 1

$V_{a+1,t+1}^{L}$ is the value of leaving teaching in CPS at age *a* + 1 and time *t* + 1

$E_t\left[Max\left(V_{a+1,t+1}^{S} + \varepsilon_{t+1}^{c}, V_{a+1,t+1}^{L} + \varepsilon_{t+1}^{e}\right)\right]$ is the expected value at *t* of being able to choose "stay" or "leave" in *t* + 1, depending on whichever has a higher realized value

The value of leaving teaching in CPS at age *a* and time *t* is $V_{a,t}^{L} + \varepsilon_t^e$, where $V_{a,t}^{L}$ is the expected value and ε_t^e is the random shock to external employment at time *t*. The expected value of leaving includes external earnings and CPS retirement benefits, if any. Thus,

$$V_{a,t}^{L} = w_a^e + \sum_{s=a+1}^{A} \beta^{s-a} w_s^e + R_{a,t}^c \quad (3.2)$$

where

w_a^e is average annual earnings in the external market at age *a*

$\sum_{s=a+1}^{A} \beta^{s-a} w_s^e$ is the present value of future external earnings through period *A*

$R_{a,t}^c$ is the present discounted value of retirement benefits accrued as a result of teaching in CPS for an individual leaving at age *a* and time *t* with total service as a teacher in CPS *t*

Consistent with policy, equation 3.2 assumes that to claim CPS teacher retirement benefits, the individual must have left CPS.[10]

An individual decides to continue teaching in CPS at age a and time t if the value of staying is greater than the value of leaving, or

$$\text{Stay at age } a \text{ and time } t \text{ if } V_{a,t}^{S} + \varepsilon_t^c = max\left(V_{a,t}^{S} + \varepsilon_t^c, V_{a,t}^{L} + \varepsilon_t^c\right)$$

This expression is not an expected maximum but a simple maximum because the shocks in t have been realized and are known to the decision maker. Thus, the probability of staying a teacher in CPS at age a at time t is

$$Pr_{a,t}(Stay) = Pr\left(V_{a,t}^{S} + \varepsilon_t^c > V_{a,t}^{L} + \varepsilon_t^e\right) = Pr\left(\varepsilon_t^e < \varepsilon_t^c + V_{a,t}^{S} - V_{a,t}^{L}\right)$$

With the shock terms assumed to have an extreme value distribution with zero mean and scale parameter λ, there is a closed-form expression for the stay probability (Train, 2003):

$$Pr_{a,t}(Stay) = \frac{e^{\frac{V_{a,t}^{S}}{\lambda}}}{e^{\frac{V_{a,t}^{S}}{\lambda}} + e^{\frac{V_{a,t}^{L}}{\lambda}}} \qquad (3.3)$$

Under the assumption that shocks are independent draws from period to period and between stay and leave, probabilities of the form (3.3) can be multiplied together to obtain the likelihood of continuous retention in CPS for any given number of years. The probabilities implicitly include teacher taste, which is unobserved. However, under the assumption that the taste of new entrants into CPS follows a normal distribution, we can integrate the probability over taste to obtain an expected probability for a teacher. It is a function of the parameters of the taste distribution, i.e., the mean and variance of taste.

---

[10] In some public defined benefit systems, it is possible to retire and begin collecting retirement benefits, but continue working as a part-time or contract employee after a certain time away. In Texas, for example, a retiree can return to work after a 12-month break and continue to draw retirement benefits. A district must contribute 14.5 percent of salary to the Texas Retirement System, which contrasts to contributions for non-retired teachers where the state contributes 6.8 percent, the member 7.7 percent, and the school district 1.5 percent. The district may reduce the teacher's salary to cover part of the 14.5 percent (Texas Classroom Teachers Association, 2016). In CPS, a retiree may return to work and continue receiving retirement benefits. This must be as a temporary and non-annual employee for CPS and/or one or more Chicago charter schools, and the employee may work no more than 100 days per year or earn more than a total $30,000 per year from any employer(s) (Chicago Teachers' Pension Fund, 2016). A return to work could be handled in our model by altering the choice in the *Emax* expression so that in periods when a teacher is eligible for retirement, based on age and years of service, the choice is between continuing as a teacher, retiring for an external position or to leave the labor market, or retiring to return as a part-time employee in the school district. We do not model returning retirees but treat them as leavers.

Summarizing, the model parameters include the mean and variance of taste, the scale parameter of the shock distribution, and the personal discount factor. The estimated version of the model also includes an early career taste factor to obtain a good fit during the first years of teaching. This adds another parameter to estimate.

Finally, the CPS data we use, described in the next section, includes both newly entering teachers for years 1992 through 2000, as well as incumbent teachers as of 1992, all followed through 2012. Because retirement ages occur at the end of the career while new teachers tend to be young, none of the new entrants in our data have accumulated enough years of service by 2012 to be eligible to retire, implying that the data would not include retention decisions over retirement years. Consequently, we adapted the DRM described above to allow inclusion of incumbent teachers among the estimation sample. To do this, we derived expressions for the taste distribution conditional on years of service. With expressions for the conditional taste distribution, we then developed career retention likelihoods for incumbent teachers, given their years of service in 1992, in the same fashion as done for new entrants, described above. The retention likelihoods are discussed in Appendix A.

Policy Simulations

An objective of the research is to simulate the effect of VRI on teacher retention and on the CPS budget. The DRM can be used to simulate the retention decisions of an entering cohort of teachers. A teacher is represented by draws from the taste distribution. A teacher knows the expected annual earnings over a teaching career and over a non-teaching career, and the terms of the teacher retirement benefit system, specifically, the eligibility conditions for early and normal retirement and benefit amount. In addition, because the teacher faces uncertainty in each period, there are draws from the shock distributions for teaching and non-teaching for each period. The teacher knows the shock draws in the current period but not in the future periods, and knows the shock scale. The teacher is rational and forward-looking and can compute the expected value of the maximum of the choice between teaching and non-teaching in the next period. That computation, however, requires the *Emax* in the next-plus-one period, which requires the *Emax* the next-plus-two period, and so forth to the end of work life. In the simulation, the teacher makes these computations and arrives at values for $V_{a,t}^{S}$ and $V_{a,t}^{L}$. These values along with current wages, the current shocks, and the teacher's own knowledge of his or her taste, enable a choice between staying in teaching or leaving.

As time passes, teacher years of service and age increase. As years of service increase, current pay increases and expected retirement benefits increase, both because of years of service and pay. As age increases, the teacher nears the window of retirement eligibility. This also means that the present value of future retirement benefits increases because they are discounted for fewer years until being received. Two factors in the DRM may cause teachers of the same age, years of service, and expected pay to behavior differently, i.e., some might choose to stay and others might choose to leave. These factors are the taste for teaching and the shock draws.

For each simulated teacher, a stay/leave decision is made in each year of service until the teacher leaves. This produces a retention profile for the teacher. We aggregate these profiles to represent the retention profile for an entering cohort of teachers, giving the number of teachers at each year of service, and this is scaled to reflect the size of the teacher workforce. The simulation is done under current pay and retirement conditions and under alternative conditions such as changes to retirement benefits, enabling a comparison of retention under one policy versus another.

Simulating the VRI raises several challenges. VRI is an unanticipated, one-time offer. It can be expected to increase the number of retirements in the year it is offered, thereby decreasing the number of retirement-eligible teachers retained in following years relative to baseline retention. Therefore, we developed simulation code to show not only the immediate impact on retention—that is, the number of VRI takers—but also the impact in subsequent years. In the simulation code, retirement-eligible teachers are given VRI choice in a given academic year, and only in that year. Because VRI had not been present in prior years, it does not enter into to the $V_{a,t}^{S}$ calculation. Similarly, in the code, VRI is offered only once and does not enter $V_{a,t}^{S}$ in years after that academic year; the simulation reverts to the ex ante policy. With this extension of the simulation code, it is possible to compute the impact of VRI in the year it is offered and in subsequent years.

Related to this, the simulation needs to identify teachers that are retirement-eligible in the academic year when VRI is offered. An entry cohort is assumed to consist of teachers entering CPS at ages 22 through 30. Because teachers have different ages at entry, both age and years of service will differ among teachers when VRI is offered. This affects the number of teachers eligible to retire at that time and their individual retirement benefit amount. It also affects the VRI lump sum payment. The simulation code must handle every case.

Finally, policy makers want to know how VRI affects the operating budget. This requires code to compute the cost of the incentive, which depends on the specific amount paid to each taker and the number of takers, and the costs avoided in future years as the retirees in the year VRI is offered are replaced by new teachers who are lower paid. A valuable feature of the simulation and cost capability is its capability to predict the number of teachers that would have retired in the absence of VRI. The number of additional teachers induced to retire by the VRI can then be calculated, as can the rent paid to teachers receiving a VRI payment but who would have retired without it.

4. Data and Parameter Estimates

Chicago Teacher Retention Data

Data on Chicago Public School teachers come from the Teacher Service Record (TSR) database of the Illinois State Board of Education (ISBE). The data include a unique identifier for each teacher, which allows us to create a teacher-level retention profile for each teacher. We use the data to identify entering cohorts of teachers and observe teacher age, total creditable years of service, breaks in service, salary, and exit from teaching in Chicago. We analyze CPS teacher retention for teachers who were aged 22 to 30 when they entered CPS. The estimation sample combines teachers that entered CPS in years 1992 to 2000 and were aged 22 to 30 at entry, along with incumbent teachers in 1992 who started their Illinois teaching career in CPS between 1971 and 1991 and were aged 22 to 30 at entry. The final year of data is 2012. In the 1992 to 2000 entry cohorts, eighty percent of the entrants were female, and the average age of entrants was 26. Fifty-six percent of the entrants were white non-Hispanic, 22 percent were black, non-Hispanic, and 18 percent were Hispanic. Most of the teachers, 69 percent, were educated in Illinois. At entry, 88 percent of the teachers had a bachelor's degree and 11 percent had a master's degree or higher. By the last observation, 42 percent had a bachelor's and 58 percent had a master's or higher. The 1992 incumbents were on average 41 years old in 1992, 77 percent were female, 78 percent were educated in Illinois, 59 percent had a bachelor's degree and 41 percent had a master's or higher. At the last observation, 36 percent had a bachelor's and 64 percent had a master's or higher. Additional descriptive statistics are available in Knapp et al. (2016).

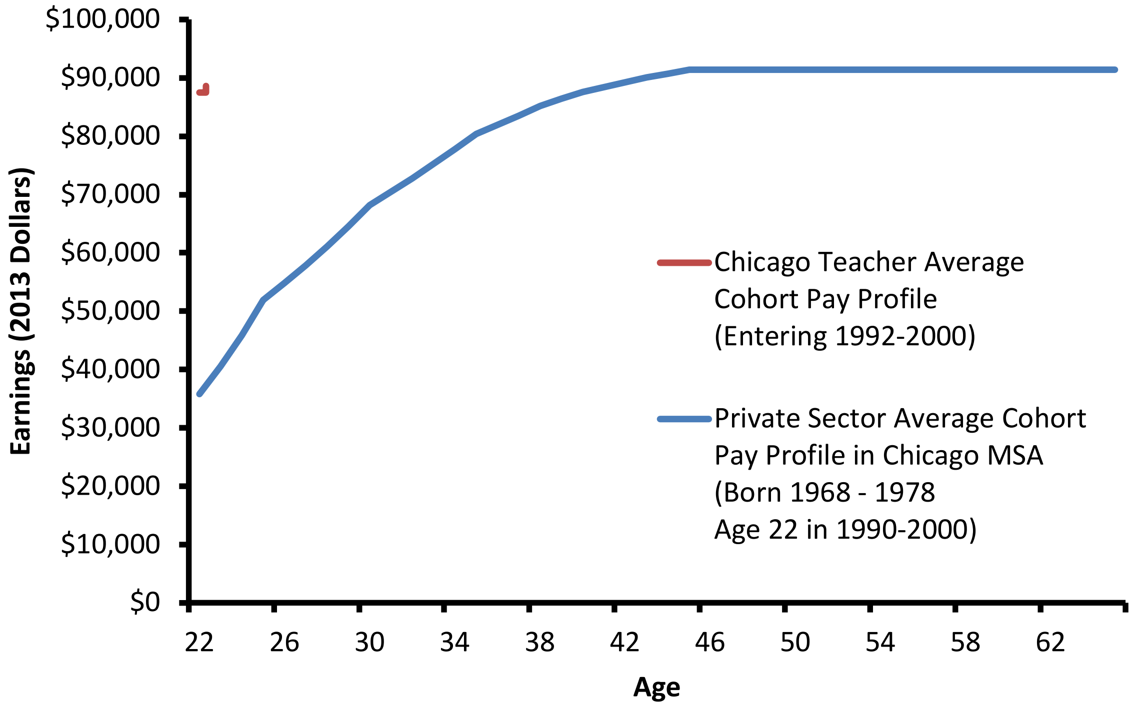
Teacher and Non-Teacher Earnings by Age

We estimated the Chicago teacher earnings with the salary information from the TSR data. We used this information to generate cross-sectional earnings profiles from 1979-2012. We estimated an ordinary least squares regression with a piecewise linear specification in years of service interacted with degree level, bachelor's or master's. We did this separately for each year and included only full-time teachers in the sample. We used the cross-sectional earnings profiles to create earnings profiles by teachers' entry cohort. For a given entry cohort Y, first-year earnings came from predicted earnings for the first year of service in the year Y cross-sectional pay profile, second-year earnings came from predicted earnings in the second year of service in the year Y+1 cross-sectional pay profile, and so on until the individual reached 34 years of service or fiscal year 2012, the last observed year. Earnings after 2012 were projected using the nearest cohort's earnings growth for the unobserved years of service (in terms of age).[11] All earnings were discounted to 2013 dollars using the annual averages for the consumer price index-urban (CPI-U) of the Bureau of Labor Statistics. Predicted earnings increase rapidly in the first 20 years of the career—the first half—then taper off to virtually no increase over the second-half of the career.

The Current Population Survey (1962-2014) was used to construct teachers' expected earnings profiles for non-CPS employment. We estimated a tobit model that allows earnings to vary by year, birth-cohort, educational attainment, metropolitan location, and in particular Chicago metropolitan statistical area, accounting for top-coding for high earners. The model estimates were applied to the sample of individuals working in the Chicago metropolitan statistical area with a BA degree to predict the earnings profiles. We freeze earnings at age 45, as the model would otherwise predict an earnings decrease. The predicted decrease likely results from selection out of working at older ages. The earnings profile in age is very similar to that for teaching in CPS. The starting salary for a young worker is lower in non-teaching but grows faster at first. Teacher and non-teacher earnings are nearly equal over ages 28 to 38 and continue growing. Earnings growth for both flattens by the early 40s. From the mid 40s to age 65 teacher earnings increase from about $87,000 to $88,600, and non-teacher earnings increase in parallel but are $3,000 to $4,000 higher. The resulting earnings profiles are averaged and presented in Figure 4.1 for a representative birth cohort (i.e., age 22 in 1990-2000).

[11] We estimate the teacher earnings regressions in terms of years of service rather than age because the TSR data include years of service information. However, we do not have years of service information in the Current Populations Survey used to estimate the non-teacher earnings profile so we use age instead. To put both profiles in the same units, the predicted earnings profile for teachers is expressed in terms of age rather than years of service.

Figure 4.1: Earnings Profiles



Parameter Estimates

The parameter estimates are given in Table 4.1 along with standard errors and z-scores. All estimates are statistically significant. The parameters for the mean and standard deviation of taste, shock location, and early career taste factor are denominated in thousands of dollars. Exploratory estimations in our earlier work (Knapp et al., 2016) suggested that taste for teaching evolves with experience and has a high value in the initial years of teaching. In view of this, we include an early career taste factor that allows taste to be high at the beginning of the career and decline as years of service increase. A specification that worked well assumes a linear reduction in this factor over the first twelve years of service, equal to $\max\left\{\psi - \frac{\psi}{12} \times \text{ years of service, } 0\right\}$. The factor is zero at twelve years of service and at that time taste reverts to the persistent mean taste. Figure 4.2 shows that the estimated model fits the teacher retention data well and accounts for high attrition among early-career teachers and the decrease in retention at 34 years of service.

The estimates imply that average taste for teaching at year of service two, for example, is about $49,700. This value, computed as $\mu + \frac{10}{12}\psi$, is roughly equal to teacher salary in the first few years of teaching (Table 2.1). Mean taste among retained teachers evolves because of the selective retention on persistent taste and the decrease in the early taste factor. As the entry cohort progresses through its career, some teachers who were a part of the entry cohort will exit teaching to pursue other opportunities. The mean taste of those who remain will increase, not only because individual tastes change over time in our model, but also because those with lower taste are less likely to stay. The standard deviation of persistent taste is $49,780. Just as the mean of persistent taste increases because of selective retention as years of service increase, the standard deviation of persistent taste also decreases.

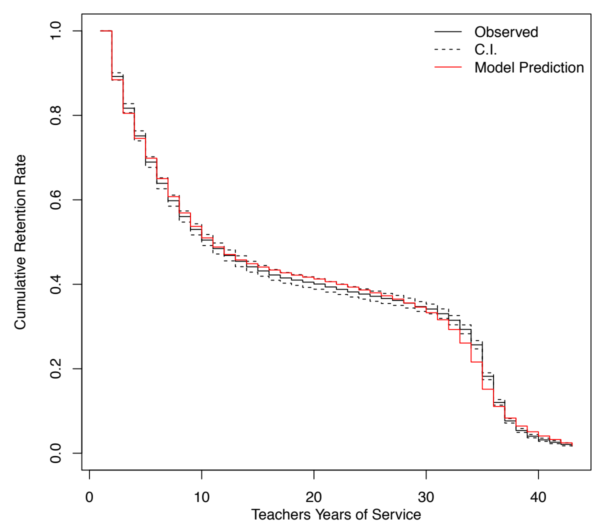
The shock scale parameter estimate is $68,290. (The mean of the shock parameter is zero in our implementation of the DRM.) The standard deviation of the shock is $\pi\lambda/\sqrt{6}$ times this amount, or $87,580. The estimate of the personal discount factor is 0.9457, implying that someone would trade $100 in compensation next year for $94.57 in current compensation. The personal discount factor is equivalent to a personal discount rate of 5.74 percent.

Table 4.1. Parameter Estimates and Standard Errors

Parameter	Estimate	Standard error	z-score
Taste			
Mean	-8.61	1.44	-5.98
Standard deviation	49.78	1.17	42.55
Shock scale	68.29	1.61	42.42
Personal discount factor			
Logit form*	2.86	0.0331	86.40
Transformed	0.946		
Early career taste factor	69.42	3.01	23.06

* We estimate the personal discount factor using a logit function to bound it between zero and one, and then transform the estimate.

Figure 4.2. Observed and Predicted Teacher Retention



5. VRI Retention Effects, Cost, and Cost Savings

We divide our VRI simulations into two parts. The first is concerned with the retention response to a range of VRIs that differ in their generosity. Here, we ask how many more teachers will retire under each incentive relative to the number that would have retired at baseline in the absence of VRI, what is the cost of paying the incentive, what is the cost of hiring the replacements, and how are CPS budget outlays affected. The second part concerns the cost and budget cost savings of the specific VRI implemented by CPS, assuming it attains the number of takers required to trigger VRI payments. The CPS VRI offers $1,500 per year of service and requires 1,500 takers to be implemented.

Range of VRIs

Table 5.1 shows the VRIs we simulate. The rate per year of service covers a broad range, from $1,000 per year to $5,000 per year.

Table 5.1. Alternative VRIs

Rate per year of service
$1,000
$2,000
$3,000
$5,000

Consider first a VRI of $1,000 per year. Table 5.2 shows that the number of retirement-eligible teachers at baseline in 2017 is 2,696.[12] Of these, the DRM predicts that 430 would retire at the end of 2017/beginning of 2018, leaving 2,266 teachers who were retirement-eligible in 2017 still teaching in 2018. Under the VRI, 530 teachers would retire, leaving 2,166 teachers from this retirement-eligible group still teaching in 2018. The $1,000 per year VRI increases retirements by 100 teachers. However, the VRI would be paid to all 530 retiring teachers.

[12] The sample used for the policy simulations was based on CPS elementary, junior high, high school, and special education teachers present in the last year of the longitudinal sample we used to estimate the dynamic retention model, which was 2012. We used the estimated model to simulate retention forward to 2017. There were 5,758 teachers present in FY 2012 with an age and years of service combination that would qualify them to be eligible to retire in FY2017. Of these, 2,696 were projected to be present in FY 2017. This number is close to the number in the CTPF Actuarial Report, namely, 2,741 (Nicholl, Strom, Robinson, 2016); However, the actual number eligible would have been larger because, in addition to these teachers, others were also eligible for the VRI: kindergarten teachers, related service personnel (clinicians), and counselors (Chicago Teachers Union, 2017).

Table 5.2. Retention of Retirement-Eligible Teachers Under the Baseline and Under VRI of $1,000 per Year

Fiscal year	Baseline	$1,000 per year
2017	2,696	2,696
2018	2,266	2,166
Retirements	430	530

Thus, we find that at a VRI of $1000 per year, relatively few additional retirement-eligible teachers would retire. To build intuition for the low responsiveness to a $1,000 per year VRI, we compare the present discounted value of retiring versus continuing to teach for some illustrative cases, shown in Table 5.3.

To compute the present discounted values, we assume a retiring teacher immediately begins drawing a retirement benefit from CTPF, and we assume the now-former teacher works at an external job through age 66, as assumed in the DRM.[13] A teacher not retiring continues to teach through age 66.[14] While teaching, the teacher receives the teacher salary and the monetary equivalent of the taste for teaching. The teacher then retires and receives a CPS retirement benefit reflecting the additional years of service in CPS.

The calculations in Table 5.3 are affected by the terms of the retirement system. From Table 2.2 the normal age of retirement is age 55 with 33.95 or more years of service, age 60 with at least 20 years of service, or age 62 with at least 5 years of service, and the early age of retirement is age 55 with at least 20 years of service. The benefit is reduced by 6 percent for each year of age below age 60 or each year of service below 33.95, whichever is less. Further, the table uses the estimated personal discount factor of 0.946, a teacher salary of $88,602, the expected value of taste for teaching conditional on years of service, and an external salary of $91,393. These salaries are the values used in estimation for ages 55 and older. The average value of taste is higher for teachers with longer retention. For example, for teachers with 20, 25, 30, and 35 years of service in the VRI decision year, the average values of taste are $30,706, $33,164, $36,415, and $49,246. The latter value is quite high because only teachers with the highest taste continue to teacher after maxing out their retirement benefits and forgoing benefit receipt for each year they continue teaching.

[13] An external job here represents the next best alternative, and so could also be thought of as the value of leisure should the individual not continue to work.

[14] Because the additional years of teaching are deterministic in the table, the table calculations do not reflect the generality of the DRM where the teacher makes a stay/leave choice in each future year and the value function includes the option value of this choice. Consequently, the table calculations understate the value of staying in teacher. Still, the table usefully illustrates the difference in the present discounted value of the income streams from leaving with a VRI compared to staying.

The columns in Table 5.3 are the teacher's age in the VRI decision year, and the rows are the teacher's years of CPS service at that time. The cell entries are the difference between (a) the present discounted value of staying to teach through age 66, retiring, and receiving the CPS retirement benefit, and (b) leaving to work at an external job through age 66 and immediately receiving the CPS retirement benefit (exclusive of any VRI). The benefit calculations account for years of service at the time the teacher retires and the reduction for early retirement, if any. A positive cell entry means that the value of continuing to teach exceeds the value of retiring from teaching. A negative value means that, at the average taste used in computing the table, it pays to leave. The negative values in the table are shown in bold to make them easier to distinguish from the positive ones.

Several features stand out in the table. Given age, the net value of staying is positive and largest at 20 years of service and decreases as years of service increase and becomes negative at higher years of service. Given years of service in the range of 20 to 25, the net value of staying tends to decrease as age increases, though remains positive. For years of service above 25, the net value of staying has a complex relationship to age—better seen in Table 5.4.

Table 5.4 shows the VRI rate per year of CPS service needed to offset the positive amounts in Table 5.3. This is the rate such that, given a teacher's years of service, the VRI payment would equal the net value of staying. The VRI rates are higher in the cells for years of service 20 to 25, where the net value of staying (Table 5.3) is higher. The blank cells in the table indicate that no VRI is needed because the net value of staying is negative. If VRI schedules are defined in increments of $1,000 per year, a cell entry of, say, $260 requires a VRI rate of $1,000 per year while an entry of $1,337 requires a VRI rate of $2,000 per year. As can be seen, in many cases with 20 to 30 years of service and ages 55 through 57 a VRI rate above $3,000 per year is needed. By comparison, for 24 or more years of service and age 60 or more, a rate of $1,000 appears sufficient. Implicitly, the table indicates that the number of VRI takers will depend on the distribution of retirement-eligible teachers by age and years of service.

Table 5.3. Illustrative Calculations of Net Present Value of Staying to Teach vs. Accepting VRI

Years of						Age					
service	55	56	57	58	59	60	61	62	63	64	65
20	161170	99206	86012	74020	63165	53366	50291	46023	40436	33394	24747
21	179936	116579	77987	65894	55134	45641	43656	40541	36172	30416	23131
22	199807	135170	69587	57422	46787	37633	36772	34844	31731	27304	21422
23	221445	155603	88799	49140	38614	29780	30024	29265	27387	24265	19764
24	205370	177988	110034	41143	30701	22161	23483	23862	23188	21338	18182
25	189179	160024	132880	62930	22703	14466	16874	18402	18941	18375	16575
26	173185	142245	113361	86686	14849	6900	10379	13039	14775	15474	15010
27	157542	124796	94150	65761	39794	**-433**	4089	7851	10753	12683	13522
28	142461	107875	75432	45290	17620	**-7393**	**-1874**	2944	6960	10070	12155
29	127868	91413	57141	25214	**-4193**	**-30891**	**-7552**	**-1720**	3368	7610	10893
30	61363	76303	40110	6301	**-24945**	**-53438**	**-30216**	**-5668**	365	5605	9942
31	**-7308**	8056	24296	**-11488**	**-44673**	**-75063**	**-52069**	**-27763**	**-2069**	4038	9292
32	**-76352**	**-60712**	**-44179**	**-26703**	**-62053**	**-94581**	**-72069**	**-48272**	**-23116**	3475	9329
33	**-144209**	**-128534**	**-111965**	**-94449**	**-75934**	**-110957**	**-89304**	**-66416**	**-42220**	**-16644**	10392
34	**-205854**	**-190689**	**-174659**	**-157714**	**-139801**	**-120866**	**-100850**	**-79691**	**-57325**	**-33682**	**-8689**
35	**-155036**	**-142935**	**-130144**	**-116622**	**-102329**	**-87220**	**-71248**	**-54364**	**-36517**	**-17651**	2292

Note: Cell entries are in dollars. Authors' calculations. Negative values are in bold for ease of reading.

Table 5.4. Illustrative Calculations of VRI Rate (Dollars per Year of Service) Needed to Offset Net Present Value of Staying to Teach vs. Accepting VRI

Years of						Age					
service	55	56	57	58	59	60	61	62	63	64	65
20	8059	4960	4301	3701	3158	2668	2515	2301	2022	1670	1237
21	8568	5551	3714	3138	2625	2173	2079	1931	1722	1448	1101
22	9082	6144	3163	2610	2127	1711	1671	1584	1442	1241	974
23	9628	6765	3861	2137	1679	1295	1305	1272	1191	1055	859
24	8557	7416	4585	1714	1279	923	978	994	966	889	758
25	7567	6401	5315	2517	908	579	675	736	758	735	663
26	6661	5471	4360	3334	571	265	399	501	568	595	577
27	5835	4622	3487	2436	1474		151	291	398	470	501
28	5088	3853	2694	1617	629			105	249	360	434
29	4409	3152	1970	869					116	262	376
30	2045	2543	1337	210					12	187	331
31		260	784							130	300
32										109	292
33											315
34											
35											65

Source: Authors' calculations.

Further DRM simulations provide estimates of VRI takers by VRI generosity. Tripling the VRI rate from $1,000 per year to $3,000 per year, for instance, increases the number of takers beyond baseline from 100 to 357 (Table 5.5).

Table 5.5. Retention of Retirement-Eligible Teachers Under the Baseline and Under Alternative VRI Amounts

Fiscal year	Baseline	$1,000 per year	$2,000 per year	$3,000 per year	$5,000 per year
2017	2,696	2,696	2,696	2,696	2,696
2018	2,266	2,166	2,046	1,909	1,608
Retirements	430	530	650	787	1,088
Additional takers		100	220	357	658

The additional retirements induced by the VRI have dynamic implications for the CPS teacher workforce. The increased outflow of teachers creates a shortfall in the size of the workforce relative to the baseline number. CPS could make up part, or all, of the shortfall by hiring replacement teachers. Cost savings would be greatest if the shortfall was addressed by hiring start-of-career teachers because they begin at the lowest salary. One approach would be to immediately hire teachers equal to the number of VRI takers. This approach, shown in Table 5.6, would cause hiring to surge in the year following VRI and be lower than baseline in following years.

Table 5.6. Retention of Retirement-Eligible Teachers and New Hires Under the Baseline and Under VRI of $1,000

Fiscal year	Retention at baseline	Implied new hires at baseline	Retention under VRI	Implied new hires under VRI	Difference in new hires
2017	2696		2696		
2018	2266	430	2166	530	100
2019	1865	401	1799	367	-34
2020	1506	359	1464	335	-24
2021	1196	310	1169	295	-15
2022	920	276	904	265	-11
2023	684	236	674	230	-6

This example is easy to grasp—more leave in the VRI year so more are replaced in that year, hence fewer need to be hired in following years—but it underestimates the new hiring that would be required. Hiring an additional 100 teachers in 2018 would restore the workforce to its baseline size in that year, but because new hires have high attrition compared with senior teachers additional hiring would be needed in 2019 and following. The alternative of hiring more than 100 more in 2018 in anticipation of attrition is not attractive because of the higher salary cost of doing this. Still, following the approach of hiring 100 replacements in 2018, we next show the impact on salary cost. There are three parts to this, the decrease in salary cost for the teachers eligible to retire in 2017, which are the target population for the VRI, the increase in salary cost for the 2018 new hires, and the cost of the VRI (Table 5.7). The implication is that when the $1,000-per-year VRI is accompanied by immediate full replacement, the budget savings are negative in the first year, 2018, and negative in total through a six-year period. Replacing the additional teachers choosing to separate because of the VRI leads to a cost increase over the six-year period, not a cost reduction as hypothesized by policymakers. If there were no replacement hiring, there would be budget savings of $8.9 million (= $24.1 - $15.2).

Table 5.7. Salary Cost at Baseline and with VRI of $1,000 per Year in 2017, Including New Hires (Millions of dollars)

Fiscal year	Salary cost of teachers eligible to retire in 2017 at baseline	Salary cost of teachers eligible to retire in 2017 under VRI	Decrease in salary cost	Salary cost of replacement teachers at baseline	Salary cost of replacement teachers under VRI	Increase in salary cost	Cost of VRI	Budget savings
2017	$245	$245						
2018	$206	$197	$9.2	$21.4	$26.3	$4.9	$15.2	-$10.9
2019	$170	$164	$6.0	$43.2	$46.9	$3.7		$2.3
2020	$137	$133	$3.9	$64.1	$66.8	$2.7		$1.2
2021	$109	$107	$2.5	$83.6	$85.7	$2.1		$0.5
2022	$84	$83	$1.6	$102.4	$104.0	$1.6		-$0.06
2023	$63	$62	$0.9	$119.7	$120.9	$1.2		-$0.3
	Total decrease		$24.1	Total increase		$16.3		-$7.3

Tables 5.8, 5.9, and 5.10 respectively show retention, budget cost with replacement hiring, and budget cost without replacement hiring under a range of VRIs. In the cost tables, a positive value indicates cost savings, i.e., budget cost is below baseline cost, and a negative value indicates higher cost than baseline.

As Table 5.8 shows, a VRI of $5,000 per year of CPS service is predicted to produce 658 additional takes. With 430 retirees at baseline, the additional takers would bring the total to 1,088, a number considerably less than the 1,500 takers needed for the VRI to be implemented. Since the number of additional takers is lower for VRI rates less than $5,000 per year, it follows that over the VRI range shown in the table there would not be enough takers to implement the VRI.

There are no cost savings when the VRI is accompanied by replacement hiring, and the net cost increases over the six-year period shown grow larger as the VRI rate increases (Table 5.9). The cost increases are likely to be under-estimates. This is because high attrition of the replacements would require additional hiring to maintain the teacher workforce, hence higher cost. In contrast, when there is no replacement hiring (Table 5.10), cost savings are positive and increase as the VRI rate increases from $1,000 per year to $3,000 per year. But cost savings increase no further when the rate goes from $3,000 per year to $5,000 per year. Although more teachers take the VRI, the savings in teacher salary cost are offset by the cost of the VRI, leaving net budget savings for the $5,000-per-year VRI lower than for the $3,000-per-year VRI.

Table 5.8. Retention by VRI Generosity

Fiscal year	Baseline	$1,000 per year	$2,000 per year	$3,000 per year	$5,000 per year
2017	2,696	2,696	2,696	2,696	2,696
2018	2,266	2166	2046	1909	1608
2019	1,865	1799	1718	1623	1404
2020	1,506	1464	1410	1346	1192
2021	1.198	1169	1134	1091	985
2022	920	904	882	855	785
2023	684	674	662	645	603
Additional takers		100	220	357	658

Table 5.9. Budget Savings by VRI Generosity, with Replacement Hiring

Fiscal year	Baseline	$1,000 per year	$2,000 per year	$3,000 per year	$5,000 per year
2017	--				
2018	--	-$10.9	-$28.1	-$53.0	-$128.9
2019	--	$2.3	$5.2	$8.6	$16.5
2020	--	$1.2	$2.8	$4.6	$9.3
2021	--	$0.5	$1.1	$1.9	$4.1
2022	--	-$0.06	-$0.1	-$0.05	$0.32
2023	--	-$0.3	-$0.7	-$1.1	-$1.8
Total savings		-$7.3	-$19.8	-$39.0	-$100.6

Table 5.10. Budget Savings by VRI Generosity, without Replacement Hiring

Fiscal year	Baseline	$1,000 per year	$2,000 per year	$3,000 per year	$5,000 per year
2017	--				
2018	--	-$6.0	-$17.2	-$35.3	-$96.3
2019	--	$6.0	$13.5	$22.2	$42.4
2020	--	$3.9	$8.8	$14.7	$28.9
2021	--	$2.5	$5.7	$9.6	$19.3
2022	--	$1.6	$3.6	$6.1	$12.5
2023	--	$0.9	$2.1	$3.6	$7.5
Total savings		$8.9	$16.5	$20.9	$14.2

Summarizing, the DRM predicts 430 retirees among retirement-eligible teachers at baseline. Because these teachers would have retired without any incentive, VRI payments to them are rent (payments beyond the amount required to induce the desired response). The number of takers increases as the VRI rate increases, and the VRI of $5,000 per year of service induces 658 retirements beyond the 430 baseline retirements. However, rent also increases as the VRI rate increases.[15] Further, when junior teachers are hired to replace the additional retirements induced by VRI, there are no budget cost savings over a six-year period, and costs increase with VRI generosity. But if none of the additional retirements are replaced, there are budget costs savings and they increase with VRI generosity up to a rate of $3,000 per year and remain at that level for a VRI of $5,000 per year.

Cost and Cost Savings Assuming 1,500 Takers for a $1,500 per Year VRI

Table 5.11 reports that 588 teachers are predicted to retire at the end of the 2017 school year with a VRI of $1,500 per year of service. This means that 588 teachers are predicted to retire, which is less than the 1,500 required for the VRI to be paid. This implies that an additional 158 teachers retire due to the VRI, suggesting that up to 158 teachers might rescind their retirement plans should the VRI not be paid.[16]

[15] The 430 willing to retire without VRI receive rent of $5,000 per year of service. The 94 additional retirements under a VRI of $1,000 per year receive rent of at least $4,000 per year of service, and similarly for the additional retirements for VRIs of $2,000 per year and $3,000 per year.

[16] It is possible that not all the additional takers would rescind their retirement plan if, for example, the act of choosing to retire changes the taker's expectations about or value of retirement. This could have the effect of raising the cost of rescinding the retirement election.

Table 5.11. VRI of $1,500 per Year

Fiscal year	Baseline	$1,500 per year
2017	2,696	2,696
2018	2,266	2,108
Retirements	430	588
Additional takers		158

In this section, we consider two alternative scenarios that assume CPS is able to achieve at least 1500 takers. This would require an un-modeled factor causing retirement eligible teachers to retire from CPS. For example, these un-modeled factors could include additional pressure applied by the union on retirement eligible teachers, or a decline in value of teaching among retirement eligible teachers, perhaps due to uncertainty about CPS's budget situation or the security of his or her pension. An example of such a shock was the furlough in Winter of 2017 in the months immediately preceding the VRI offer.

The group that retires is typically a non-random sample of those eligible to retire. Table 5.4 illustrates that, generally speaking, older teachers and teachers with more experience are more likely to retire. The group that retires can have a significant impact on the cost of the VRI and the potential savings from replacing retirement-eligible teachers with new teachers. Since 430 individuals are expected to retire without a VRI, we need to identify the additional 1,070 who would retire in order to meet the contractual minimum in the CPS-CTU contract.

We consider two cases:

1. The subset of teachers induced to retire by an $X/year VRI, where X is sufficient to achieve at least 1,070 teachers
2. A random selection of at least 912 teachers from the sample of retirement eligible after the 588 retire due to the $1,500/year VRI

The first case emphasizes that, if at least 1,500 teachers choose to retire, it would likely be the teachers closest to being indifferent between retiring and continuing to teach in CPS. The second case reflects that, if at least 1,500 teachers choose to retire, it would be for un-modeled reasons, and so it could be an arbitrary sampling from those eligible to retire. These two cases represent extremes of who might accept the VRI policy. By considering these two cases, we provide a range of the potential savings that might be realized should the VRI be successful in achieving at least 1,500 retirements at the end of the 2017 school year.

First, we identify the $X in the first case by increasing the potential VRIs in $1,000 increments and use the first VRI that achieves at least 1,500 retirements (similar to the exercise in the previous section). We find that a VRI of $8,000/year achieves 1,527 retirements at the end of the 2017 school year. Next, we assume that the second case involves a random selection of

939 teachers (e.g., 1527 - 588) from the retirement eligible teachers to achieve approximately the same number of retirements.

Table 5.12 presents the retention over the next six fiscal years of the $1,500 per year VRI, as well as the two alternative cases where at least 1500 retirements are achieved at the end of the 2017 school year. As in Table 5.8, a VRI leads individuals to move up their time of retirement, meaning they retire sooner than they would have under the baseline. Therefore, by FY2023, we observe that the remaining baseline sample is close to the $1,500 per year VRI (e.g., 684 versus 668). Case 1 reflects a similar pattern of individuals "moving up" their retirement due to the VRI, however, the pattern is extended due to the size of sample exiting at the end of FY2017. Case 2 results in far greater retirements after FY2018 because the set of those retiring at the end of FY2017 includes a greater number of teachers who would have continued teaching much longer. Consequently, we can expect budget savings in case 2 to be much greater due to the composition of those who exit CPS at the end of 2017.

Table 5.13 calculates the budget savings for the cases considered in table 5.12, assuming that all teachers are replaced with new hires. As in the cases considered in table 5.9, the budget savings over the following six years are not sufficient to cover the large outlays from the VRI, resulting in negative $12.8 million in savings. Case 1 and 2, which assume that at least 1,500 teachers retire, produce large savings over this time period of $35.8 and $64.2 million, respectively. The savings become positive, as the economic rents paid to the 430 teachers that would have retired in the baseline scenario become a smaller fraction of the overall savings. The savings are larger in case 2 relative to case 1 because the teachers who are staying after FY2017 in the random sample include more retirement eligible teachers who would have retired in the next few years without the VRI.

Table 5.14 calculates the budget savings for the cases considered in table 5.12, assuming that no teachers are replaced with new hires. As in the cases considered in table 5.10, the large outlays from the VRI are easily covered by the budget saving over the following six years from a lower salary bill, resulting in $13.0 million in savings over the next six years. Case 1 and 2 find greater savings relative to this case because of the additional 1,370 teachers retired at the end of FY2017.

Table 5.12. Retention for a $1500 per year VRI and Alternative Cases Achieving 1500 Retirements

Fiscal year	Baseline	$1,500 per year	Case 1	Case 2
2017	2,696	2,696	2,696	2,696
2018	2,266	2,108	1,169	1,170
2019	1,865	1,761	1,056	959
2020	1,506	1,438	929	777
2021	1.198	1,152	793	617
2022	920	893	651	475
2023	684	668	515	352
Additional takers		158	1,527	1,526

Note: The baseline sample is comprised of teachers eligible for retirement at the end of FY2017. Case 1 corresponds to the retention of the sample assuming those who retire at the end of FY2017 are the same teachers who would have retired under an $8000/year VRI (the lowest VRI that can achieve at least 1,500 retirements). Case 2 corresponds to the retention of the baseline sample assuming those who retire at the end of FY2017 are a random sample of the teachers not retiring with a $1,500/year VRI.

Table 5.13. Budget Savings for a $1500 per year VRI and Alternative Cases Achieving 1500 Retirements, with Replacement Hiring

iscal year	Baseline	$1,500 per year	Case 1	Case 2
2018	--	-$18.6	-$19.0	-$16.2
2019	--	$3.7	$29.1	$32.6
2020	--	$1.9	$17.5	$23.0
2021	--	$0.7	$8.6	$14.8
2022	--	-$0.1	$1.84	$7.60
2023	--	-$0.5	-$2.3	$2.5
Total savings		-$12.8	$35.8	$64.2

Note: See note to table 5.12

Table 5.14. Budget Savings for a $1500 per year VRI and Alternative Cases Achieving 1500 Retirements, without Replacement Hiring

Fiscal year	Baseline	$1,500 per year	Case 1	Case 2
2018	--	-$10.8	$35.4	$38.1
2019	--	$9.6	$74.2	$82.5
2020	--	$6.3	$53.0	$66.5
2021	--	$4.0	$37.0	$52.9
2022	--	$2.5	$24.8	$40.8
2023	--	$1.5	$15.6	$30.5
Total savings		$13.0	$240.0	$311.4

Note: See note to table 5.12

In summary, the CPS VRI of $1,500 per year of service is predicted to not achieve the 1,500 retirements needed under the CPS-CTU contract for it to be paid. If it were to be paid, for reasons outside the contract, then the budget savings for CPS over the next six fiscal years would depend critically on whether the additional teachers induced to retire under the VRI were replaced. If so, savings would be negative due to the economic rents of paying the VRI to teachers who would have retired without it. But, if they are not replaced, then the savings would be positive. These results imply that the VRI, as designed in the CPS-CTU contract, provides a budget savings over a short time horizon, but only if those who leave as a result of VRI are not replaced.

We also found that who retires matters for the budget savings from a retirement incentive. A VRI appeals to individuals closest to indifference between continuing to teach and retiring. As a result, those who are incentivized to retire would have likely retired within a few years without the VRI. In order to maximize cost savings (as in comparing case 2 to case 1), the structure of a retirement incentive should appeal to those who are furthest from retirement.

Finally, we found that if CPS were successful at achieving at least 1,500 retirements, then it would obtain budget savings between $35.8 and $64.2 million over the next six fiscal years by trading more expensive senior teachers for less expensive new teachers. However, the structure of CPS teacher's compensation is unlikely to achieve the requisite 1,500 retirements, highlighting the importance of using economic tools, like the DRM, to understand the interaction of compensation and retention.

6. Recap and Closing Thoughts

Many school districts and local governments are using, or considering the use of, voluntary retirement incentives (Terrell, 2016). The intent is to decrease the payroll cost of their workforce, decrease retirement fund liability, decrease workforce size without layoffs, or a combination of these outcomes. Given the substantial amount of underfunding among state pension systems—only seven had a funding ratio of 90% or greater (Doherty, Jacobs, & Lueken, 2017)—it is likely that districts and states will continue to use retirement incentives to restructure their workforce. This research evaluates one example of a voluntary retirement incentive offered to teachers in Chicago, but the lessons learned from its design are more broadly applicable.

At the end of the 2017 school year, CPS offered a one-time, unanticipated retirement incentive. It provided $1,500 per year of service of non-pensionable income for teachers who agreed to retire immediately. A particularly unique aspect of CPS's retirement incentive was that it required at least 1,500 of the teachers eligible for retirement to retire for it to be paid to the retiring teachers. Should 1,500 teachers not elect to retire, those electing to retire will have the opportunity to rescind their retirement election.

We use a stochastic dynamic model of teacher retention behavior to predict the number of teachers willing to accept this voluntary retirement incentive and retire. The model is estimated on CPS teacher data for teachers that start their career in Chicago and accounts for current and deferred compensation, for permanent unobserved differences in a teacher's net preference, or taste, for teaching in CPS over the next best alternative, as well as uncertainty or environmental disturbances. We estimate the model with individual-level data on entry cohorts of CPS teachers from 1979-2000, which are the cohorts affected by the retirement incentive.

Our model predicts that only 588 of the 2,700 teachers eligible for the benefit will retire. We examine the sensitivity of our results to different levels of a VRI, ranging from $1,000 to $5,000 per year of service and find that in all cases, budget savings will be negative if all of the teachers incentivized to retire by the VRI are replaced. However, savings can be positive if not all of them are replaced.

Our research reveals two important dimensions to consider in the design of a VRI. First, since a district cannot know what teachers would retire without an incentive, a VRI results in economic rents: payments to individuals who would have retired without the incentive. We find that 73 percent of the retirements that would be generated from Chicago's $1,500 per year VRI would be among individuals who would have retired even without the incentive. The second is that cost savings from a VRI depends crucially on the extent to which voluntary retirement incentives induce individuals to retire earlier than they would have in the absence of the incentive. Depending on the terms of the retirement incentive and teacher's responsiveness to them, the retirement rate could be high yet the cost savings could be low or even negative. We presented two cases, one where individuals selected into retirement due to a VRI that was substantial enough to encourage 1,500 retirements, and another involving the random selection into retirement. The individuals selecting into retirement did so due to diminishing returns from retirement benefits (e.g. reaching the maximum pension multiplier) or a lower permanent preference for teaching, which would have led them to retiring soon without an incentive. Consequently, compared to the random sample, cost saving are only 56 percent as large due to selection. A challenge to policy design is that a teacher's expected time of retirement is private information.

This research finds that cash incentives intended to exchange more expensive senior teachers for less expensive more junior ones are broadly ineffective when those senior teachers are covered by a system that embeds strong pension incentives to delay retirement until a specific age. A more cost-effective policy would highlight incentives to leave early while discouraging economic rents. For example, a VRI could be limited to individuals who are eligible for reduced pension benefits by paying them a substantively higher rate, or by altering their penalty for collecting benefits early, or a combination of both. Such a policy could combine deferred expenses on the part of the school district with immediate costs savings.

Finally, we predicted a VRI take rate of 22 percent (= 588 / 2,696). This was close to the realized rate of 27 percent.[17] Our prediction was therefore near the actual value, though slightly lower. The accuracy of the prediction helps to validate dynamic retention modeling as a capability for simulating the retention and cost effects of policies affecting the structure of compensation, including policies such as the VRI for which there was no historical precedent.

[17] News reports indicated " …about 840 teachers had submitted retirement notices" (Perez, 2017) and a little more than 3,100 teachers" were eligible to retire (FitzPatrick, 2017). These numbers imply a take rate of 27 percent (= 840/3,100). Our analysis sample is smaller than 3,100 because it did not include kindergarten teachers, temporary assigned teachers, related service personnel (clinicians) or counselors, nor did it include teachers entering CPS after 2012 (the final year of our data) with years of service from a district that had reciprocity with CTPF, or teachers on a temporary leave of absence in 2012.

Appendix A: Probability of Staying

We do not observe individuals' tastes for teaching in the CPS or random shock terms. Instead, we assume they are each distributed according to known types of probability distributions with unknown parameters that we estimate using available data. Specifically, we assume individuals' tastes for teaching in CPS are normally distributed and the random shocks have an extreme-value type 1 distribution. Given these distributional assumptions, we can derive choice probabilities for each alternative at each decision year and the cumulative choice probabilities or survival probabilities for an entering cohort at each decision year, and then write an appropriate likelihood equation to estimate the parameters of the model. These include the standard deviation of the probability distribution for the shock terms, the mean and standard deviation for the distribution of taste for teaching in the CPS for new-entrant teachers at entry, and the discount factor.

We next present the choice probabilities, the cumulative retention probabilities, and the likelihood equation. The extreme-value distribution, $EV[a, b]$, has the form $\exp(-\exp((a - x)/b))$ with a mean of $a + b\Gamma$ and a variance of $\pi^2 b^2/6$ (or a standard deviation of $\frac{\pi b}{\sqrt{6}} \approx 1.28b$), where Γ is Euler's Gamma (approximately 0.577), a is the location parameter, and b is the scale parameter. We assume the shock terms have a zero mean and scale λ, implying that they have the extreme-value distribution $EV[-\Gamma\lambda, \lambda]$, i.e., $a = -\Gamma\lambda$ and $b = \lambda$. Both ε_t^e and ε_t^c have an extreme value distribution, and the difference $\varepsilon_t^e - \varepsilon_t^c$ in Equation 3.3 is known to have a logistic distribution. With this information, the expected value of the maximum has a closed form:

$$E_t\left[Max\left(V_{a+1,t+1}^S + \varepsilon_{t+1}^c, V_{a+1,t+1}^L + \varepsilon_{t+1}^e\right)\right]$$
$$= \iint Max\left(V_{a+1,t+1}^S + \varepsilon_{t+1}^c, V_{a+1,t+1}^L + \varepsilon_{t+1}^e\right) d\varepsilon_t^c d\varepsilon_t^e$$
$$= \lambda ln\left[e^{\frac{V_{a+1,t+1}^S}{\lambda}} + e^{\frac{V_{a+1,t+1}^L}{\lambda}}\right]$$

Substituting this into the expected value of staying (equation 3.1), we have

$$V_{a,t}^S = \gamma^c + w_t^c + \beta\lambda ln\left[e^{\frac{V_{a+1,t+1}^S}{\lambda}} + e^{\frac{V_{a+1,t+1}^L}{\lambda}}\right] \tag{A.1}$$

Thus, we have an explicit expression for the value function, given (unobserved to the analyst) taste for teaching in CPS, γ^c. The expression on the right-hand side of (A.1) is used in model estimation when recursively evaluating the probability that a teacher chooses to stay at age *a* and having reached time *t*

$$Pr_{a,t}(Stay) = \frac{e^{\frac{V^S_{a,t}}{\lambda}}}{e^{\frac{V^S_{a,t}}{\lambda}} + e^{\frac{V^L_{a,t}}{\lambda}}} \quad \text{(A.2)}$$

The probability of leaving at age *a* and time *t* is $1 - Pr_{a,t}(Stay)$.

Given independent shock draws in each period, the cumulative probability that a CPS teacher entering at time 0 with age *a* will stay through *t* - 1 may be written[18]

$$cumulativePr(Stay)_{a,t} = \prod_{s=0}^{t-1} Pr_{a+s,a+s+1}(Stay)$$

The cumulative probability that a CPS teacher who enters at age *a* stays for *t* – 1 years and leaves at *t* is

$$cumulativePr(Leave)_{a,t} = \prod_{s=0}^{t-2} Pr_{a+s,a+s+1}(Stay)(1 - Pr_{a+t-1,a+t}(Stay))$$

These probabilities are conditioned on the unobserved taste parameter, γ^c. We assume the taste parameter has a normal distribution $g(\gamma^c)$ with mean μ and standard deviation σ. We use this information to formulate the expected cumulative probability of a given career path, or the likelihood of that path. Thus, for a teacher in our data who enters teaching at age *a*, stays through *t* – 1 and leaves at *t*, the likelihood of that career path is

$$\mathcal{L}_i(\mu, \sigma, \lambda, \beta) = \int_{-\infty}^{\infty} \prod_{s=0}^{t-2} Pr_{a+s,a+s+1}(Stay)(1 - Pr_{a+t-1,a+t}(Stay))\, g(\gamma^c) d\gamma^c \quad \text{(A.3)}$$

The subscript *i* in $\mathcal{L}_i$ denotes the *i*th teacher. Similarly, if the individual stays through *t* and is then censored, the likelihood is

$$\mathcal{L}_i(\mu, \sigma, \lambda, \beta) = \int_{-\infty}^{\infty} \prod_{s=0}^{t-1} Pr_{a+s,a+s+1}(Stay)\, g(\gamma^c) d\gamma^c$$

Thus, the likelihood for the entire data sample, N, is given by

$$\mathcal{L}(\mu, \sigma, \lambda, \beta) = \prod_{i=1}^{N} \mathcal{L}_i(\mu, \sigma, \lambda, \beta)$$

---

[18] At entry, each teacher is assumed to decide to stay for the first period. In other words, when a teacher enters, it is assumed that the teacher has in effect decided to stay for the first period: $Pr_{a+0,1}(Stay) = 1$. Hence, the first stay/*leave* decision occurs at the beginning of the second period.

The discussion so far is relevant to a population observed at entry into teaching in CPS at the beginning of a career and assumes that members of the population are represented by the same taste distribution. Extending the DRM to incumbent teachers recognizes that their taste distribution is conditional on having taught for some years. In our particular extension, we want to add incumbent teachers present in the first year of our sample who joined CPS as a new entrant in an earlier year, and we maintain the assumption that their taste distribution at entry was the same as the taste distribution of current new entrants. Under this assumption, we can express their conditional taste distribution in terms of the new entrant taste distribution and the cumulative probability of individuals with a given taste staying in CPS until the year of service when they are first observed, and this allows us to incorporate incumbent teachers into our sample and likelihood function.

The density of taste, γ^c, at the start of year of service t conditional on staying continuously from entry to t is

$$p(\gamma^c|s_0, s_1, \dots, s_{t-1}) = p(\gamma^c, s_0, s_1, \dots, s_{t-1})/p(s_0, s_1, \dots, s_{t-1})$$

$$= p(s_0, s_1, \dots, s_{t-1}|\gamma^c)g(\gamma^c)/p(s_0, s_1, \dots, s_{t-1}) \quad \text{(A.4)}$$

Here, $p(s_0, s_1, \dots, s_{t-1}|\gamma^c)$ is the probability that a teacher stays continuously to complete $t-1$ years of service (i.e., stays to the beginning of period *t*) given a particular value of taste drawn at entry into CPS. As before, the density of taste for new entrants is $g(\gamma^c)$. The denominator, $p(s_0, s_1, \dots, s_{t-1})$, is the probability of staying continuously to complete $t-1$ years of service averaged over all values of taste, that is, taste is integrated out.

The DRM is a first-order Markov process, so the probability of staying in $t-1$ given that one has stayed continuously from entry through $t-2$ is just the probability of staying in $t-1$ given staying in $t-2$, and so forth. The expression in the numerator of (A.4) can then be written

$$p(s_0, s_1, \dots, s_{t-1}|\gamma^c) = p(s_{t-1}|\gamma^c)p(s_{t-2}|\gamma^c) \dots p(s_0|\gamma^c)$$

Also, the denominator in (A.4) is this probability averaged over taste:

$$p(s_0, s_1, \dots, s_{t-1}) = \int_{-\infty}^{\infty} p(s_{19}|\gamma^c)p(s_{18}|\gamma^c) \dots p(s_0|\gamma^c)g(\gamma^c)d\gamma^c$$

These results imply that (A.4) can be written as

$$p(\gamma^c|s_0, s_1, \ldots, s_{t-1}) = \frac{p(s_{t-1}|\gamma^c)p(s_{t-2}|\gamma^c)\ldots p(s_0|\gamma^c)g(\gamma^c)}{\int_{-\infty}^{\infty} p(s_{19}|\gamma^c)p(s_{18}|\gamma^c)\ldots p(s_0|\gamma^c)g(\gamma^c)d\gamma^c}$$

The usefulness of this expression for the conditional probability of taste given some period of stay (left-hand side) comes from breaking it into a product of per-period stay probabilities of known form times the a priori taste distribution, also of known form (assumed to be normal), divided by an average value that can be computed from the same expressions.

Using the conditional density for taste for an incumbent teacher's years of service as of 1992, we can construct probability expressions for the incumbent's retention decisions in years from 1992 forward in the same fashion as done for new entrants, where the unconditional density of taste was used. For example, consider teachers who served continuously from entry and were making a stay/leave decision at the beginning of year of service 20 in 1992. These teachers began in 1973 and had already completed 19 years of service. The conditional taste distribution for these teachers is

$$\frac{p(s_{19}|\gamma^c)p(s_{18}|\gamma^c)\ldots p(s_0|\gamma^c)g(\gamma^c)}{\int_{-\infty}^{\infty} p(s_{19}|\gamma^c)p(s_{18}|\gamma^c)\ldots p(s_0|\gamma^c)g(\gamma^c)d\gamma^c}$$

In developing the likelihood for these teachers, this taste distribution is used in place of $g(\gamma^c)$ in (A.3) and their retention decisions are tracked from 1992 through 2012, the last period observed in the data set.

References

Ahern, Mary Ann, & Bremer, Shelby (2017). Illinois Senate Passes Education Funding Reform Deal. Chicago, IL: NBC Chicago.

Chicago Public Schools. (2016). Chicago Public Schools Fiscal Year 2016 Budget. Retrieved from http://cps.edu/fy16budget/Pages/pensions.aspx

Chicago Public Schools. (2017). Chicago Public Schools Fiscal Year 2017 Budget Chicago, IL: Chicago Public Schools.

Chicago Teachers' Pension Fund. (2016). Returning to Work. Retrieved from http://www.ctpf.org/retired_members/reemployment.htm

Chicago Teachers' Pension Fund. (December 24, 2017). Current News. Retrieved from http://www.ctpf.org/current_news/currentindex.htm

Chicago Teachers Union (2017). Retirement Incentive Deadline Friday, March 31. Retrieved from https://www.ctunet.com/blog/retirement-incentives

Doherty, Kathryn M., Jacobs, Sandi, & Lueken, Martin F. (2017). *Lifting the Pension Fog: What Teachers and Taxpayers Need to Know about the Teacher Pension Crisis*. National Council on Teacher Quality.

FitzPatrick, Lauren. (2017). CPS May Pay $50M to Entice Older Teachers to Retire in June. *Chicago Sun-Times*. Retrieved from https://chicago.suntimes.com/chicago-politics/cps-may-pay-50m-to-entice-older-teachers-to-retire-in-june/

Hansen, Janet S. (2010). An Introduction to Teacher Retirement Benefits. *Education Finance and Policy, 5*(4), 402-437.

Kilroy, Meaghan. (2016a). Chicago Pension Reform Bills Stall as State Legislatirue Adjourns; Lame-duck Vote Possible. *Pensions & Investments*. Retrieved from http://www.pionline.com/article/20161205/ONLINE/161209937/chicago-pension-reform-bills-stall-as-state-legislature-adjourns-lame-duck-vote-possible

Kilroy, Meaghan. (2016b). Illinois Governor Vetoes Funding Bill for Chicago Teachers Pension Fund. *Pensions & Investments*. Retrieved from http://www.pionline.com/article/20161201/ONLINE/161209983/illinois-governor-vetoes-funding-bill-for-chicago-teachers-pension-fund

Knapp, David, Brown, Kristine, Hosek, James, Mattock, Michael G., & Asch, Beth J. (2016). *Retirement Benefits and Teacher Retention: A Structural Modeling Approach*. Retrieved from Santa Monica, Calif.:

McKinney, Dave, & Pierog, Karen. (2017). Far-reaching Illinois Budget Fix Faces Long Odds. *Reuters*. http://www.reuters.com/article/us-illinois-budget-idUSKBN1581OM

Nicholl, Kim M., Strom, Matthew A., & Rubinson, Yori. (2016). Public School Teachers' Pension and Retirement Fund of Chicago: Actuarial Valuation and Review as of June 30, 2016. *Segal Consulting*, 76.

Perez Jr., Juan. (2018, April 13, 2017). CPS Retirement Incentive Plan Fails to Draw Desired Number of Participants *Chicago Tribune*. Retrieved from http://www.chicagotribune.com/news/local/breaking/ct-chicago-teacher-retirement-incentive-met-20170413-story.html

Segal Consulting. (2016). *Public School Teachers' Pension and Retirement Fund of Chicago: Actual Valuation and Review as of June 30, 2016*. Chicago, Illinois.

Terrell, Jessica. (2016). Make Early Retirement Enticing to Teachers. *District Administration*. https://www.districtadministration.com/article/make-early-retirement-enticing-teachers.

Texas Classroom Teachers Association. (2016). TRS Contributions. Retrieved from https://tcta.org/node/13108

Train, Kenneth. (2003). *Discrete Choice Methods with Simulation*. New York, N.Y.: Cambridge University Press.