Online Appendix to "How Much Are Public School Teachers Willing to Pay for Their Retirement Benefits? Comment"

Shawn Ni, University of Missouri-Columbia
Michael Podgursky, University of Missouri-Columbia and Saint Louis University
Fangda Wang, University of Missouri-Columbia

Contents

A Illinois TRS Pension Rules and the 2.2 Pension Upgrade

Before discussing the pension upgrade in 1998, we first summarize the defined benefit pension rules of public school teachers in Illinois. Illinois public school teachers are enrolled in the Teacher Retirement System (TRS) (except teachers in Chicago, who are enrolled in Chicago Teachers' Pension Fund, CTPF). The TRS teachers are classified into several tiers of pension plans. Before September 2018, there were two tiers: Tier 1 (2) are those first contributed to TRS before (after) Jan. 1, 2011 or (and) have (no) pre-existing creditable service with a reciprocal pension system prior to Jan. 1, 2011. Tier 1 and Tier 2 members are covered by defined benefit plans of different parameters. In September 2018, a new group, Tier 3, was created. Tier 3 is a hybrid of defined benefit and defined contribution plans.

Teachers can raise the replacement factor for their service years prior to July 1, 1998 to 2.2% by paying a cost. We call it the "2.2 upgrade".

The 2.2 upgrade in 1998 only concerned Tier 1 members. Pensions of Tier 1 teachers experienced several waves of pension enhancements. The 2.2 upgrade was one of them.

A.1 Eligibility for Pension

During the time of employment, teachers contribute a portion of their salary to the pension system, matched by the employer. Eligibility for pension is based on combinations of age-experience (accumulated service credit) requirement:

Table A1: Retirement Eligibility

Year of Service	Age	Description
5	62	Normal Retirement
10	60	Normal Retirement
20	55	At reduced rate: 6% for each year under 60; or under ERO*
35	55**	Normal Retirement

Note: * ERO stands for Early Retirement Options, which will be discussed later in the Appendix.
**If the retirement annuity is at least 74.6 percent of the final average salary and the teacher will reach age 55 between July 1 and Dec. 31, TRS considers him/her to have attained age 55 on the preceding June 1. Moreover, if a teacher meets some criteria of the state of Illinois, he/she can apply for rule of 85.
Source: TRS (2018a), TRS (2018b)

Vested members who do not satisfy the above requirements may retire under actuarial annuity calculation. The overall retirement qualification requirements are plotted in Figure A1.

The old and new formula after the 2.2 upgrade is depicted in Fitzpatrick (2015), which we redraw here for convenience in Figure A2.

A.1.1 Details on service credit

According to Chapter 5 of TRS (2018a), credible service years include regular service, sabbatical leave, sick leave, optional service and reciprocal service, among others. Although regular service makes up the majority of total service credit, sick leave and optional service play big role at the margin, especially when teachers make 2.2 upgrade decisions (see the table in Figure A3, extracted from TRS (2007), for the magnitude of these two items.) For example, a teacher with 36 years of regular service, 1 year of unused sick leave and 1 year of optional service, (i.e., 38 years of total service) does not need the upgrade since the old formula already gives the teacher max benefit. Neglecting the 2 additional service years of sick leave and optional service would result in a substantially higher estimate of the upgrade benefit, given the rules of the upgrade discussed later.

Figure A1: Retirement Eligibility by age and service years

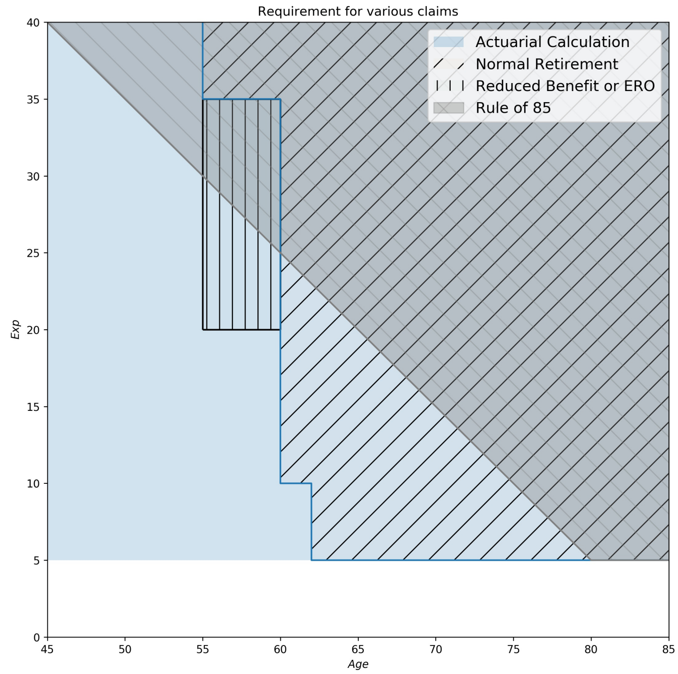
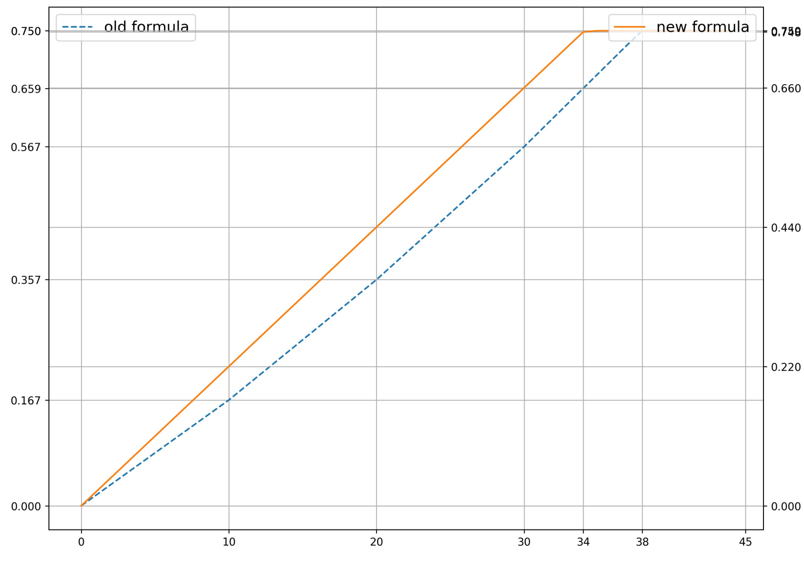


Figure A2: Old and New formula: pension benefit as the fraction of the final average salary by service years at retirement



Note: The dashed line is the old formula. The solid line is the new formula after the 2.2 upgrade.

Figure A3: Credible service years during fiscal year 2002-2006 in TRS (2007)

Page 64

TABLE 9

SUMMARY OF OPTIONAL AND SICK LEAVE SERVICE CREDIT AMONG ACTIVE SERVICE RETIREES WHO RETIRED WITH AN ANNUITY

MALES AND FEMALES
FY 2002 – FY 2006

SERVICE CREDIT AT RETIREMENT

Type of Service	Number of Retirees	Years of Service	Average Over All Retirees	As a Percent of Regular
Regular	21,985	652,738	29.690	100.00%
Optional Service	7,953	20,350	0.926	3.12%
Sick Leave	20,989	24,018	1.092	3.68%
Total	21,985	697,105	31.708	106.80%

AVERAGE AMOUNTS OF DIFFERENT TYPES OF SERVICE

Type of Service	Total Years of Service at Retirement					
	Under 20	20-24.999	25-29.999	30-33.999	34 or more	Total
Regular	13.309	20.085	24.882	29.626	33.447	29.690
Optional Service	0.616	1.440	1.720	1.359	0.613	0.926
Sick Leave	0.643	0.881	1.012	1.094	1.177	1.092
Total	14.569	22.406	27.614	32.078	35.237	31.708

AVERAGES BY FISCAL YEAR OF RETIREMENT

Fiscal Year	Optional Service	Sick Leave	Total
2002	1.028	0.840	1.868
2003	0.880	1.030	1.910
2004	0.929	1.106	2.035
2005	0.913	1.212	2.125
2006	0.866	1.269	2.135
Average	0.926	1.092	2.018

TEACHERS' RETIREMENT SYSTEM OF THE STATE OF ILLINOIS

BUCK CONSULTANTS, LLC

A.1.2 Restrictions on retirement benefit

TRS has several restrictions in the benefit formula:

1) The retirement benefit is capped at 75% of the final average salary. However, if the factor is greater than 74.6%, TRS will round it to 75%. [1]

2) There is a 20% cap on salary increases in calculation of final average salary: annual salary rate after June 30, 1979 cannot exceed the previous year's full-time rate by more than 20 percent. However, this applies only to salaries earned from the same employer.

Finally, for Tier 1 members, the retirement benefit increases at an annual compound rate of 3%.

A.1.3 Early Retirement Options (ERO) and Early Retirement Initiatives (ERI)

There are two TRS programs encouraging early retirement. Additional contributions were required from the member and employer to participate in these programs.

[1] For the actuarial calculation this cap does not apply. Thus for those with exceptionally long careers, actuarial calculation may yield a higher annuity than one based on service credit.

Early Retirement Options (ERO) was enacted on July 1, 1979 and was available until 2016. Under ERO a member between the ages of 55 and 60 with 20 or more years of service credit could retire without an early retirement reduction. (see TRS (2018a).)

Early Retirement Initiatives (ERI) allowed employees to buy an additional five years of age and service credit (see Fitzpatrick and Lovenheim (2014).) ERI was only available in 1992-1994. Because the 2.2 upgrade took place in 1998, ERI has no direct impact on teachers' decision on the upgrade.

A.1.4 Impact of pension rules on the calculation of expected benefit of the upgrade

In Fitzpatrick (2015) the benefit of the 2.2 upgrade is estimated by using retirement probability. In the main text we argue that the estimated benefit does not capture idiosyncratic factors that influence decisions on retirement and upgrade.

In addition to the omission of the unobserved heterogeneity, there are several problems in calculating the estimated benefit. The retirement probabilities are estimated from the historical data for 1988-1997 and may be a biased estimate of the retirement probabilities after 1998 due to pension rule changes:

i) The introduction of 2.2 upgrade policy itself results in changes in the timing of retirement.

ii) The new ERO policy since 2005 could also influence teacher's retirement decision (note that teachers retiring under ERO typically have less experience and hence the 2.2 upgrade is more valuable to them).

iii) The new ERO policy allows employers to limit the number of ERO retirements to 10 percent. Those prefer to retire early but cannot retire under ERO may choose the actuarial calculation instead of reduced benefit. The actual benefits of upgrading may be zero for those teachers.

iv) The ERI policy only existed in 1992-1994. Retirement probability calculated that covered this period may not be the same as that after 1998.

A.2 Details on the 2.2 upgrade

A.2.1 Cost and benefit of the upgrade

Teachers can upgrade their service year prior to 1998 by paying a price:

$$Price_{it} = \min\left(\frac{Exp_{1998}}{100}, \frac{20}{100}\right) \times Salary_{it}$$

where Exp_{1998} is the service year earned before 1998, $Salary_{it}$ is the highest salary rate during the four school years before one opt for the upgrade. Typically, this is the salary of the teacher at the time upgrade purchase. It means that the teacher pays 1% for each year of service before 1998, capped by 20%. [2]

The main effect of the 2.2 upgrade is to help teachers reach the 75% cap sooner. Under the old formula, it took 38 years of service to reach the cap. Under the new formula and the upgrade, it only takes 34 years (see Figure A2). On the other hand, the 2.2 upgrade has no value for at least three groups of teachers:

i) those are not eligible for normal, reduced normal or ERO retirement plans;

ii) those who already reached the 75% cap under the old formula;

iii) those who can collect more annuity under the actuarial calculation.

A.2.2 Reduction, refund, and restrictions on the upgrade

TRS imposed some restrictions on the upgrade (see, e.g., TRS (2019)).

i) On the amount of upgrade: a member who chooses to upgrade must upgrade all the service years prior to 1998 under the four-step formula, but the maximum charge is 20 percent, or 20 years, times the 1 percent contribution rate.

The upgrade charge can be refunded or reduced under some conditions:

ia) One may receive a refund with interest or a reduction of the 2.2 upgrade cost: For every three years with earned regular service credit after July 1, 1998, the equivalent of one year of the 2.2 upgrade cost will

[2] There is a special term for members with at least 24 years of service credit as of July 1, 1998: a member who did not take the upgrade and had at least 24 years of service prior to July 1998 would receive 2.2 percent for each year of service earned after June 1998 up to 30 years and then 2.3 percent for each year of service over 30 years.

be reduced or refunded with interest. For our sample of senior teachers, it is 1% of salary, or 1/20 of the total upgrade price.

ib) Teachers who retire with more than 34 years of service credit may receive a 25 percent reduction in upgrade costs for each year of creditable service beyond 34 years, up to a maximum of 100 percent. Partial years are prorated.

Table A2: Reduction in upgrade cost

Years of service after 98	Reduction	Years of service at retirement	Reduction
3	5%	34	0%
6	10%	35	25%
9	15%	36	50%
12	20%	37	75%
15	25%	38	100%

Note: Years of service are examples. For senior teachers, the cost is 0.2 times salary, and the reduction is as percent of cost instead of salary.

ii) The timing of upgrade: one can only upgrade before collecting any retirement benefit. In another words, "The 2.2 benefit formula does not apply to retired TRS members because they are receiving a retirement benefit."

iii) The frequency of upgrade: "You may make an election to upgrade only once during a five-year period. The election will remain in effect for five years from August 15 following your election to upgrade."

iv) The payment of upgrade can be spread out over at most 5 years according to Fitzpatrick (2015) (page 184). The maximum payment period is 24 months if paid by a reduction in retirement benefits, according to TRS (2019).

B Data Description and Sample Construction

Our main results on take-ups of the upgrade and the cost-benefit analysis are based solely on the TRS data, rather than the merged data of TSR and TRS as in Fitzpatrick (2015). Since TRS is responsible for recording creditable years of service and annual earnings for determining pension benefits as well as the 2.2 upgrade, analysis based on TRS records is appropriate. The availability of teacher payroll data by TRS makes it possible to calculate the years of service at any time, and in 1998 in particular. We discuss merging of TRS and TSR data in Section B.7 for replication of the sample statistics reported by Fitzpatrick (2015).

B.1 Data sources

Table B1: Data sources

Data	Description	Source	Time	Note
a)	teacher information in TRS	TRS	1980 to 2014	cross section
	teacher payrolls	TRS	up to 2014	panel
b)	teacher pension	TRS	2015 to 2019	panel
	2.2 upgrade information	TRS	1998 to 2019	cross section
c)	Fitzpatrick (2015) data	Fitzpatrick (2015)	as of 2009	cross section
d)	district salary table	ISBE	2010-2019	panel

Note: Teacher information in TRS includes all teachers on record between 1980-2014. Teacher payrolls and service records start their first year of service (which can be earlier than 1980). Some records were created before the electronic system was built.

The data used for this study consist of four data sets from three sources:

a) the Teachers' Retirement System (TRS) data for teachers active in 1980 to 2014

We obtain the data for teachers who are on record at least once from 1980 to 2014. [3] We have the TRS member's name, gender, age (at separation if retired, or current age otherwise), choice of the 2.2 upgrade, first day of work, last day of work, final cumulative service credit, and (if retired) retirement claim date and claim type. Moreover, for each job the member took, we have the payroll data recording the fiscal year, employer name, contract days, paid days, service credit, salary and earnings. Because the Illinois public system allows fractional service credit, one can earn

$$\min\{\frac{\sum \text{paid days}}{\text{contract days}}, 1\}.$$

The payroll data contain some records before 1980.

Data a) were requested in Feb, 2014. However, they do not include the pension benefits (although retirement claim types are recorded).

b) the TRS data on annual pension benefits and 2.2 upgrade cost up to 2019

We requested the amount of pension and the cost of 2.2 upgrade for teachers active in 1980 to 2019. We requested the data in Feb 2019, and the requested data came in several batches until June 2019. In this newly requested TRS data, the purchase date of 2.2 upgrade is "final date of purchase" which may be updated when one took refund at the time of retirement. Because there is no unique identifier of teachers in the two waves of our requested TRS data and we match them based on personal characteristics including name, first year of work, last year of work, etc.

c) the data used by Fitzpatrick (2015)

We also obtained the data and program used by Fitzpatrick (2015) from the AEJ website (available at: Fitzpatrick (2019)). Her sample period ends in 2009. We run her code on her data and obtain the same results as in her paper (with a few exceptions detailed in Section B.6). However, her data do not contain teacher name or sufficient information of other variables to allow an adequate match of her data with ours.

d) district salary tables

[3] All TRS data can be requested at: `https://www.trsil.org/FOIA/foia-public-record`.

To reconstruct the cross-district IV in Fitzpatrick (2015), we also obtain the district salary table from the ISBE website (ISBE (2020)). However, spreadsheets of salary data now went back only as far as 2010-2011, which we use instead of the 1998 salary table used in Fitzpatrick (2015).

B.2 Construct a matched sample between two TRS datasets

To calculate the cost and benefit of the 2.2 upgrade, we only need two data sets from TRS: a) and b). First, we construct the sample of senior teachers (those with 22-28 years of service in 1998) from TRS, similar to Fitzpatrick (2015). Our sample size differs slightly from hers: she has a sample of 19,429 teachers, we have 19,126. The sample size depends on the selection criteria in Table B2. Moreover, a stricter standard yields higher quality of the merged data set, which is crucial for the precision of our calculation of upgrade cost and benefit. Hence we apply the most restrictive Selection Criterion 3 and focus on the sample with 19,126 observations. Criteria 1 and 2 result in 21,261 and 19,450 observations, respectively.

Table B2: Sample selection and merging two TRS datasets

Selection Criterion	1	2	3
experience of service 22-28 in 1998	Yes	Yes	Yes
work full time in 1998	Yes	Yes	Yes
match on name	Yes	Yes	Yes
——— first year of work	No	Yes	Yes
——— last year of work	No	No	Yes
——— total service credit at retirement	No	No	Yes
retire by 2014	No	Yes	No

Note: Experience in 1998 is calculated as the cumulative sum of service credit by 1998, not including sick leaves, optional credit, etc. We require exact match for name and allow fuzzy match on other variables. Work full time in 1998 means the total service credit earned in 1998 should be 1.

B.3 Detailed procedures

step 1: selection based on data set a) TRS data up to 2014

With the TRS payroll data, we first obtain teachers who had worked in the 1997-1998 school year (those who have earned at least 0.006 service credit, i.e., one work day in 1997-1998), and their service credits in every fiscal year. TRS provides the final years of service but not the cumulative years of service by 1998. We calculate the latter by adding the annual service credits. One may earn fractional service credit from multiple employers in the same year, we first add all the service credit for one year (if it is greater than 1, we record it as 1), keep those with 1 service credit for 1997-1998, and then calculate the cumulative sum up to that time.

There are two potential issues: first, we may miss those working part time in 1997-1998. By the policy rules, they are eligible for the upgrade as long as they have not collected the retirement benefit. Second, since the service credit can be fractional, we round them to integers: so 22 years of experience may include teachers with in fact 21.50-22.49 years of experience. For robustness check against the first issue we include teachers who work part time in 1998. To address the second issue, we first select those with 21-29 years of service at the end of 1997-1998 school year and round their service credit to integers. Then we select those with 22, 23,..., 28 years of service credit at 1998 to create an alternative sample.

Accuracy of our service credit calculation

To verify that our calculation of the service credit is consistent with that of TRS, we compare the final service credit calculated using our approach with the total service credit reported by TRS. We find that the mean error is -0.003, indicating our service credit calculation is quite accurate. This suggests our calculation of the service credit in 1998 is likely accurate.

step 2 merge with data set b) TRS data on pension and upgrade up to 2019

We follow Selection Criterion 3 and match on name, first year of work, last year of work, total service credit and select those retired by 2014.

step 3 descriptive statistical analysis

With this sample, we can track teachers to 2019 and record their retirement claim types, retirement date, upgrade decisions, and the date of upgrade purchase. We divide the sample into takers and non-takers and examine the difference in age and experience across the subgroups. Moreover, we further decompose the non-taker group by their retirement claim types and repeat the comparison in age and experience. The results are reported in Tables 1-2 and Figures 2-3 in the text and various tables in the Appendix.

B.4 Robustness check of sample construction

Before describing how we calculate the upgrade cost and benefit in the next section, we discuss some alternative criteria for data matching and procedures for robustness. Here, we only report the results for replication of Table 1 in the text.

B.4.1 observations with exact years of service of 22-28

As noted earlier, Illinois allows fractional years of service and we round the years of service in 1997-1998 to integers, which may cause measurement errors. We build another restrictive sample with years of service exactly equal to 22, 23, ..., 28 in 1997-1998. That sample has 11,114 observations and we replicate the analysis in the main context on this data set. The result for this robustness check is reported in Table B3.

B.4.2 teachers work part time in 1997-98

As we noted in step 1 of Section B.3, some teachers may have worked part time in school year 1997-1998 and we excluded them from our sample. Here we include them in the sample and repeat the analysis. The result for this robustness check is reported in Table B4.

B.4.3 alternative selection criteria

We use several alternative selection criteria and repeat our quantitative analysis for samples obtained from those criteria:

i) Instead of using the cumulative service credit, we assume that one year equals one service credit, no matter how many service credit one actually earns. The result is in Table B5.

ii) We include all teachers with 20-29 years of service at the end of 1997-98 school year and report the result in Table B6.

Table B3: Replicating Table 1 for teachers with exact years of service in 22, 23, ..., 28 at 1998

type	number	percent	average cost	average benefit	average net benefit	median net benefit
taker	9530	85.75%	15.81	122.46	106.65	105.37
non-taker	1584	14.25%	14.34	4.13	-10.21	-12.96
non-taker-retired	1351	12.16%	14.28	4.84	-9.44	-12.88
whole sample	11114	100.0%	15.60	105.59	89.99	95.30

Table B4: Replicating Table 1 by including for teachers working part time in 1998

type	number	percent	average cost	average benefit	average net benefit	median net benefit
taker	16733	86.78%	15.23	121.57	106.33	104.74
non-taker	2550	13.22%	13.80	4.38	-9.43	-12.67
non-taker-retired	2175	11.28%	13.76	5.13	-8.63	-12.56
whole sample	19283	100.0%	15.04	106.07	91.03	96.59

Table B5: Replicating Table 1 by restricting one year = one service credit

type	number	percent	average cost	average benefit	average net benefit	median net benefit
taker	17235	86.57%	15.00	121.04	106.03	104.13
non-taker	2673	13.43%	13.32	4.40	-8.92	-12.44
non-taker-retired	2258	11.34%	13.25	5.21	-8.04	-12.33
whole sample	19908	100.0%	14.78	105.37	90.60	95.90

Table B6: Replicating Table 1 for teachers with 20-29 years of service at 1998

type	number	percent	average cost	average benefit	average net benefit	median net benefit
taker	23364	86.24%	15.11	120.15	105.04	103.03
non-taker	3727	13.76%	13.66	4.49	-9.18	-12.61
non-taker-retired	2941	10.86%	13.67	5.68	-7.99	-12.48
whole sample	27091	100.0%	14.91	104.24	89.33	94.48

The robustness checks confirm two patterns reported in Table 1 in the text. First, the overall take-up rate is around 85%. Second, the average net benefit of upgrade is negative for non-takers and positive and large for takers.

B.5 Calculating cost and benefit of 2.2 upgrade

B.5.1 Benefit of upgrade

We contrast our calculation of the benefit of the upgrade with Fitzpatrick (2015). We use the actual benefit after observing the retirement decision, Fitzpatrick (2015) uses an estimated benefit based on retirement probability.

B.5.2 Calculation of the "actual" benefit of the upgrade

$$B = \sum_{i=0}^{T-a-i} \frac{1.03^i \pi(a+i|a)\Delta B_i}{1.051^i} \tag{1}$$

step 1: obtaining ΔB_i

We use the observed actual annual retirement benefit for 2018 to recover the actual benefit at the time of retirement claim. For takers, we calculate the benefit they would receive at the time of retirement claim without the upgrade and subtract it from the actual benefit, to obtain the benefit of upgrade, ΔB. For non-takers, we calculate the benefit they would receive at the time of retirement claim with the upgrade and subtract it with the actual benefit. Note that at retirement claim date, the final average salary as well as the total service credit are determined, hence our calculation of the potential retirement benefit without the upgrade is straightforward.

step 2: computing the present value weighted by mortality and the real discount rate

We use gender-specific mortality rate and the real discount rate of 1.03/1.051 to calculate the discounted expected value of the upgrade. T is the maximum lifespan (set at 101 years), a is age at the year of retirement $\pi(a+i|a)$ is the probability of surviving to age $a+i$ for a teacher of age a.

step 3: converting to 2010 dollars

Finally, we convert the value at the time of retirement claim to 2010 dollars by CPI inflation.

B.5.3 Calculation of "estimated" benefit of the upgrade

Following Fitzpatrick (2015) we calculate estimated benefit weighted by retirement probability at year j based on the following formula:

$$B^* = \sum_{j=0}^{T-a-j} \frac{1.03^j \pi(a+j|a)(\Delta B_j) R_j}{1.051^j} \tag{2}$$

step 0: estimating the wage schedule and retirement probability

The pension benefit depends on the salary at the time of retirement. Thus the benefit of the upgrade for a teacher who will retire in the future depends on future salary. Teacher salary is highly predictable by experience. Here we use a regression to estimate salary schedule. We obtain a cross section of teacher salary in different years by experience and regress the logarithm of salary on a cubic function of experience. The salary at year j is fitted value for $e+j$ multiplied 1.03^j to adjust for inflation.

The retirement probability R_j across time for a teacher with initial age-exp (a, e) in 1997-98 is approximated by teachers with the same age and experience at an earlier period (for example, late 1980's to early 90's). We track the teachers in the earlier period over time and record their retirement years. We use the frequency of retiring in year j as the estimate of retirement probability in year j.

step 1: obtaining ΔB_j for each $j = 0, ..., T-a$

Now we can calculate the pension benefits (with or without upgrade) if one retires at year j, and the additional pension benefit from the upgrade, with the estimated salary schedule.

steps 2 and 3 are similar to those in subsection B.5.2

step 4: weighting by retirement probability

Finally, we weight the expected discounted benefit by retirement probability for all feasible years j to obtain the one used in Fitzpatrick (2015).

B.5.4 Cost of the upgrade

The date of purchase in our data set from TRS is the date of final transaction. We were informed by TRS that the record for the first date of purchase is unavailable. We estimate the first date of purchase using data on the final payment of 2.2 upgrade and the number of years of service purchased. Dividing the former by the latter gives us the salary in the year of purchase. We then compare that salary with the payroll data for each teacher to find the closest match, which corresponds to the year of first purchase.

The estimated first purchase is likely earlier than the reported date of the final transaction by TRS, which may be for a later payment or rebate for the upgrade. But the final transaction occurs only when the upgrade was purchased earlier. Hence for a given cohort the cumulative take-up rate for a given year based on the estimated first upgrade purchase is higher than that based on the final transaction date.

The estimated upgrade purchase date may contain errors but this is a minor issue for two reasons. First, there is no ambiguity in "whether" a teacher took the upgrade. Second, our robustness checks show that "when" the upgrade took place is empirically unimportant in the calculation of the cost and benefit of the upgrade.

For robustness check to the purchase date, we calculate the upgrade cost with two extreme timings of the purchase of upgrade. And we convert both costs to 2010 dollars.

cost paid at retirement

We assume the upgrade the cost is paid at the time of retirement. For our sample of senior teachers, it is 20% of the annual salary at the time of retirement minus potential reductions for service credit after 1998 as well as total service credit exceeding 34.

cost paid in 1998

This is 20% of salary in 1997-1998.

Finally, note that the actual cost may be between the two cases and it is possible to spread the payment over a period up to 24 months and deduct it from the retirement benefit. But the cost difference at the different timing of upgrade does not materially change net benefit of the upgrade.

B.5.5 Four cases for calculating cost and benefit

We have two methods for calculating upgrade cost and and two for benefit, hence four cases in total:

Table B7: Four measures of upgrade cost and benefit calculation

benefit / cost	at 1998	at retirement claim
actual benefit based on formula (1)	Table B8	Table B9
estimated benefit based on formula (2)	Table B10	Table B11

Note: Table B10 and Table B11 use the retirement probability and salary growth based on the 1991 data.

Table B8: Summary Statistics by Types of Teachers, alternative decomposition

type	number	percent	average cost	average benefit	average net benefit	median net benefit
taker	16654	87.08%	15.26	121.55	106.30	104.77
non-taker	2472	12.92%	14.00	4.41	-9.60	-12.76
non-taker-retired	2106	11.01%	13.97	5.17	-8.80	-12.65
non-takers-with-benefit	120	0.63%	13.83	84.60	70.77	49.32
whole sample	19126	100.0%	15.09	106.41	91.32	96.83

Note: The "takers" are those taking the 2.2 upgrade eventually in our sample, up to 2019. The "non-takers" are those not taking it by 2019; "non-takers retired" are those retired by 2014; "non-takers with benefit" is a subgroup of "non takers retired" who were eligible for the upgrade with positive net benefit but failed to upgrade. All values are in $1000 2010 dollars.
Our detailed retirement-related data (including final average salaries and total years of service, which are essential in determining the potential gain of upgrade) are up to 2014. We label active teachers who have not purchased the upgrade by 2014 as non-takers, because for a teacher with at least 22 years of experience in 1998 and worked continuously to 2014 would have a service year of 38 would not benefit from the upgrade.
Average price (cost) is calculated assuming all teachers upgrade in 1998, following Fitzpatrick (2015); the results with price of upgrade at retirement claim date are in Table B9.
The average benefit for takers is the present value of the actual benefit minus the potential benefit without the upgrade; for non-takers, it is potential benefit with upgrade minus the actual benefit. Note that for non-takers, the potential benefit of not upgrading is the maximum of two options: one for old formula and another for actuarial calculation.
We use the same nominal rate of 5.1% as Fitzpatrick (2015). This along with the cost of living adjustment of 3% implies the real discount factor: $\beta = 1.03/1.051 = 0.980$ or $r = 1/\beta - 1 = 0.020$.

Table B9: Summary Statistics by Types of Teachers, with upgrade cost at retirement claim date

type	number	percent	average cost at claim	average benefit	average net benefit	median net benefit
taker	16,654	87.08%	16.55	121.55	105.01	102.73
non-taker	2,472	12.92%	2.84	4.41	1.57	0.00
non-taker-retired	2,106	11.01%	3.33	5.17	1.84	0.00
non-takers-with-benefit	431	2.25%	3.38	25.03	21.65	2.22
whole sample	19,126	100.0%	14.77	106.41	91.64	95.74

Note: The cost and benefit are in $1,000 2010 dollars. Average cost at claim is the payment one has to make for upgrade at the time of retirement claim. It depends on the salary one earned for the last year of work, and takes into account potential reduction and refunds. These reduction and refunds include discount for those with total service credit greater than 34 years at retirement, as well as for years of service after 1998.

Table B8 presents a finer decomposition of Table 1 in the text. Table B9 uses the cost at retirement claim date for the upgrade cost.

Tables B10 and B11 show that using the weighted average calculation of the upgrade benefit, the gap in the average benefit between takers and non-takers shrinks to around $10k, and most of those non-takers have positive net benefit, with the cost at paid in 1998 or at retirement claim. Moreover, the upgrade benefit seems to distributed uniformly across teachers with different years of service at 1998.

Table B12 compares the average actual benefit at different discount rate and the weighted average benefit with retirement probability and salary based on the 1991 data.

Table B10: Summary Statistics by Types of Teachers, estimated benefit, and upgrade cost in 1998

type	number	percent	average cost	average benefit	average net benefit	median net benefit
taker	16,654	87.08%	15.26	117.06	101.80	97.00
non-taker	2,472	12.92%	14.00	107.84	93.84	89.41
non-taker-retired	2,106	11.01%	13.97	106.98	93.01	88.32
non-takers-with-benefit	2,469	12.91%	14.00	107.97	93.97	89.41
whole sample	19,126	100.0%	15.09	115.87	100.77	95.77

Note: All measurements are the same as Table 1 in the text, with two exceptions. Upgrade cost is measured by 20% of the salary in 1998; and upgrade benefit is measured by the weighted average with retirement probabilities and salary growth of the 1991 cohort.

Table B11: Summary Statistics by Types of Teachers, estimated benefit, and upgrade cost at retirement

type	number	percent	average cost at claim	average benefit	average net benefit	median net benefit
taker	16,654	87.08%	16.55	117.06	100.51	95.44
non-taker	2,472	12.92%	2.84	107.84	105.01	99.92
non-taker-retired	2,106	11.01%	3.33	106.98	103.65	98.61
non-takers-with-benefit	2,469	12.91%	2.83	107.97	105.14	99.94
whole sample	19,126	100.0%	14.77	115.87	101.09	96.06

Note: Upgrade cost is based on payment at the time of retirement claim, net of possible refund/reductions.
Benefit is the weighted average with retirement probabilities and salary growth both from the 1991 cohort.

Table B12: Actual Benefit and Estimated Benefit

exp at 98	actual benefit	actual benefit 7.1%	actual benefit 9.1%	prob 91 slry 91	number of teachers
22	93.55	74.96	61.98	117.52	2385
23	96.49	77.27	63.85	117.80	2430
24	104.52	83.61	69.04	116.16	2897
25	109.80	87.83	72.53	112.11	3006
26	112.71	90.10	74.36	113.91	2972
27	113.59	90.86	75.03	117.61	2599
28	110.89	88.70	73.24	116.94	2837
whole sample	105.94	84.76	70.00	116.01	19126

Note: Actual benefit based on formula (1) with different discount rates: 5.1%, 7.1%, and 9.1%.
"prob91 slry 91": benefit uses the weighted average (formula (2)) with retirement probabilities and salary growth both from the 1991 cohort.

B.6 Working with the data and code in Fitzpatrick (2015)

Using the data and code provided at the AEJ website (Fitzpatrick (2019)) we are able to replicate the results of Fitzpatrick (2015) for the most part, with some discrepancies in the calculation of take-up rate. Because her data set does not contain teacher names, we are not able to extend the records of the same cohort by merging her data with our data.

B.6.1 Replicating summary statistics in Table 1 of Fitzpatrick (2015)

The original program from the AEJ website does not reproduce Table 1 in Fitzpatrick (2015). Table B13 is produced with the data and code from the AEJ website. The sample size in Table B13 is 20,350, instead of 19,429 reported in Table 1 in Fitzpatrick (2015).

We managed to replicate her Table 1 by using one criterion for sample selection for the upgrade and retirement probability and another for the cost and benefit of the upgrade. This is reported in Table B14. Table B14 matches Table 1 in Fitzpatrick (2015) very closely with one exception that the retirement ratio for those with 22 years of service at 1998 is 0.51, instead of 0.6 reported in her paper. In Table B13 the retirement ratio for those with 22 years of service at 1998 is also 0.51.

Figure B1: Original Table 1 of Fitzpatrick (2015)

TABLE 1— TAKE-UP RATES, RETIREMENT RATES, PRICES, AND COSTS BY LEVEL OF EXPERIENCE IN 1998

Years of experience in 1998	Fraction who retire by 2009	Fraction who purchase upgrade by 2009	Mean price [$1,000s] (SD)	Mean benefit [$1,000s] (SD)	Mean ratio of benefits to price (SD)	Observations
22	0.6	0.7	14.02	86.06	6.29	2,409
			(4.08)	(28.41)	(2.87)	
23	0.67	0.71	14.61	90.41	6.27	2,589
			(4.35)	(30.62)	(1.99)	
24	0.78	0.76	14.90	93.01	6.27	2,991
			(4.40)	(31.55)	(1.20)	
25	0.83	0.78	15.26	96.94	6.37	3,121
			(4.51)	(33.62)	(1.26)	
26	0.88	0.77	15.40	100.40	6.54	2,909
			(4.47)	(35.39)	(1.43)	
27	0.89	0.74	15.75	102.73	6.53	2,674
			(4.73)	(37.56)	(1.37)	
28	0.91	0.73	15.90	102.17	6.42	2,736
			(4.63)	(36.42)	(1.27)	
Whole sample						19,429

Notes: Based on the author's calculations using data from Illinois TRS and TSR. Years of service in 1998 is the number of creditable years of service the teacher has accrued by 1998. The fraction who retire is the fraction of the teachers with the indicated number of years of experience in 1998 who have begun collecting retirement benefits as of 2009. The fraction who purchased the upgrade is the fraction of teachers with the recorded amount of service who have purchased the upgrade by 2009. The average price of the upgrade is based on the teacher's salary and experience at the time of purchase (and is in thousands of 2010 US dollars). The cost of the upgrade (in thousands of 2010 US dollars) is the present value in 1998 of the extra retirement benefits paid out as of 2009 as explained in the text.

Table B13: Replication of Fitzpatrick (2015) Table 1 with the code from the AEJ website

Years of experience in 1998	Fraction who retire by 2009	Fraction who purchase upgrade by 2009	Mean price [$1,000s] (SD)	Mean benefit [$1,000s] (SD)	Mean ratio of benefits to price (SD)	Observations
22	0.51	0.69	13.79	85.22	6.39	2542
			(4.19)	(28.31)	(2.96)	
23	0.66	0.71	14.42	89.63	6.35	2711
			(4.44)	(30.51)	(2.15)	
24	0.77	0.75	14.73	92.24	6.35	3141
			(4.48)	(31.44)	(1.51)	
25	0.82	0.78	15.08	96.10	6.45	3267
			(4.57)	(33.53)	(1.53)	
26	0.87	0.77	15.21	99.37	6.61	3042
			(4.55)	(35.32)	(1.70)	
27	0.89	0.74	15.58	101.72	6.58	2795
			(4.78)	(37.30)	(1.59)	
28	0.90	0.73	15.73	101.23	6.47	2852
			(4.69)	(36.28)	(1.48)	
Whole sample						20,350

Note: The table is produced with the code and data labeled for Table 1 from the AEJ website.

Table B14: Replication of Fitzpatrick (2015) Table 1 with revised code

Years of experience in 1998	Fraction who retire by 2009	Fraction who purchase upgrade by 2009	Mean price [$1,000s] (SD)	Mean benefit [$1,000s] (SD)	Mean ratio of benefits to price (SD)	Observations
22	0.51	0.70	14.02	86.06	6.29	2409
			(4.08)	(28.41)	(2.87)	
23	0.67	0.72	14.61	90.41	6.27	2589
			(4.35)	(30.62)	(1.99)	
24	0.77	0.76	14.90	93.01	6.27	2991
			(4.40)	(31.55)	(1.20)	
25	0.83	0.79	15.26	96.94	6.37	3121
			(4.51)	(33.62)	(1.26)	
26	0.88	0.77	15.40	100.40	6.54	2909
			(4.47)	(35.39)	(1.43)	
27	0.89	0.75	15.75	102.73	6.53	2674
			(4.73)	(37.56)	(1.37)	
28	0.90	0.73	15.90	102.17	6.42	2736
			(4.63)	(36.42)	(1.27)	
Whole sample						19,429

Note: The table is produced with a revised code that uses a different sample-selection criterion (which is used to generate the sample for the regression analysis in Fitzpatrick (2015) Table 2) from the AEJ website.

B.6.2 Two measures of takers of upgrade

More importantly, in her programs there are two variables recording the upgrade decisions. Fitzpatrick (2015) used "takeupgrade" for the summary statistics in her Table 1 and "takeUPmiss" for the regression analysis in her Table 2. There are missing values of "takeupgrade", and for those not missing, "takeupgrade" coincides with "takeUPmiss". There are no missing values in "takeUPmiss".

In Table B15, for "takeupgrade" and "takeUPmiss", "1" means a teacher took the upgrade, and "0" means a teacher did not take the upgrade, "n.a." means missing value for "takeupgrade". Table B15 shows that 1,735 out of the 5,535 (or 31%) non-takers categorized by "takeUPmiss" have missing values in "takeupgrade", and 2400 out 13,894 (about 17%) takers have missing values in "takeupgrade".

Table B16 shows that the missing value of "takeupgrade" is perfectly correlated with the observed retirement behavior. All the teachers with missing "takeupgrade" are not retired.

Table B15: "takeupgrade" and "takeUPmiss"

	takeupgrade			
takeUPmiss	n.a.	0	1	Total
0	1735	3800	0	5535
1	2400	0	11454	13894
Total	4175	3800	11454	19429

Note: The first (second) row decomposes those with "takeUPmiss" being 0 (1) into different values of "takeupgrade". The columns decomposes those with a given value of "takeupgrade" into different values of "takeUpmiss".

Table B16: "takeupgrade" and "retire"

	takeupgrade			
retire	n.a.	0	1	Total
0	4175	0	0	4175
1	0	3800	11454	15254
Total	4175	3800	11454	19429

Note: The first (second) row decomposes those with "retire" being 0 (1) into different values of "takeupgrade". The columns decomposes those with a given value of "takeupgrade" into different values of "retire".

In Table B14, we use the indicator upgrade "takeupgrade" that contains missing values. We redo her Table 1 using "takeUPmiss" as indicator for the upgrade decision. The result is reported in Table B17. The fraction of takers is lower than that in Table B14, as is expected.

Finally, we revisit the question of take-up rate. The take-up rate in Table 1 of her paper (here in Figure B1) is 74.3%. Table B18 reports sample composition based on the count of "takeUPmiss". The take-up rate of 71.5% is lower than that based on "takeupgrade".

B.7 Supplemental tables of cumulative take-ups by year

The data we have for tracking the upgrade decision is up to 2019, however, the retirement claim data we have is up to 2014. Table B19 tracks upgrades for the subgroup of teachers retired by 2014 and for the whole sample.

There are classification errors for non-takers. We remove teachers with five types of retirement claims in the subgroup of "non-takers by 2019" to build the subgroup of "true non-takers by 2019": "Regular 2.2", "2.2 ERO Employer Pay", "2.2 ERO Member Pay", "Rule of 85 - 2.2", and "Regular 2.2 - Disability". These claims are only available for teachers who took the upgrade. There are 322 such teachers. We call the remaining non-takers true non-takers. The eventual take-up rate (by 2019) based on the TRS record given in Table B19 is 1 minus the eventual true non-takers (12.92%), which results in a take-up rate of about 87%.

Table B17: Replication of Fitzpatrick (2015) Table 1 with revised code and measure the upgrade decision by "takeUPmiss"

Years of experience in 1998	Fraction who retire by 2009	Fraction who purchase upgrade by 2009	Mean price [$1,000s] (SD)	Mean benefit [$1,000s] (SD)	Mean ratio of benefits to price (SD)	Observations
22	0.51	0.72	14.02	86.06	6.29	2409
			(4.08)	(28.41)	(2.87)	
23	0.67	0.70	14.61	90.41	6.27	2589
			(4.35)	(30.62)	(1.99)	
24	0.77	0.73	14.90	93.01	6.27	2991
			(4.40)	(31.55)	(1.20)	
25	0.83	0.74	15.26	96.94	6.37	3121
			(4.51)	(33.62)	(1.26)	
26	0.88	0.72	15.40	100.40	6.54	2909
			(4.47)	(35.39)	(1.43)	
27	0.89	0.70	15.75	102.73	6.53	2674
			(4.73)	(37.56)	(1.37)	
28	0.90	0.69	15.90	102.17	6.42	2736
			(4.63)	(36.42)	(1.27)	
Whole sample						19,429

Note: The table is produced with a revised code that uses an alternative sample-selection criterion (which is used to generate the sample for the regression analysis in her Table 2) from the AEJ website. In addition, the indicator for the upgrade decision is "takeUPmiss" instead of "takeupgrade".

Table B18: Recalculated Summary Statistics by Types of Teachers in Fitzpatrick (2015)

type	number	percent of total	average cost	average benefit	average net benefit
taker	13894	71.51%	15.49	101.20	85.71
non-taker	5535	28.49%	14.27	90.86	76.59
non-taker-retired	3800	19.56%	14.41	98.12	83.71
non-takers-with-benefit	5532	28.47%	14.27	90.91	76.63
whole sample	19429	100.00%	15.14	98.26	83.11

Note: The table is produced with the data from the AEJ website but with "takeUPmiss" as the take-up indicator.

Table B20 decomposes the true non-takers by the retirement claim types. Table B21 compares the retirement and upgrade data in Fitzpatrick (2015) and our sample. Table B21 is based on the estimated first upgrade purchase. Fitzpatrick (2015) indicated that her sample period ends in 2009 without giving the exact date. We consider two extreme cases for the end of sample period: one is at the end of 2008 and another at the end of 2009. The estimate of the cumulative take-up rate based on the estimated first date of purchase given in Table B21 is 85%, the same for 2008 and 2009. The cumulative take-up rates based on the final transaction dates supplied by TRS are in Table B22. As noted in Section B.5.4, some of purchases occurred before the final transaction dates. Hence the take-up rates in Table B22 are lower than the cumulative actual rates by the year.

As noted earlier, our calculation of the take-up rate of final transaction date is based on the TRS records and is robust to the end of sample period. The cumulative take-ups by our estimated first purchase date plateaued by 2008. One may ask why the take-up rate calculated by Fitzpatrick (2015) is about 11% lower than ours. [4]

We discussed above the missing value of take-up indicators in the data used by Fitzpatrick (2015) that can affect the take-up rate. But a more likely explanation is that merging TRS with TSR creates a discrepancy in the samples defined by service credits of 22-28 years in 1998. As mentioned earlier, TRS provides the final cumulative service for retired members and current cumulative service for active members. We calculated the cumulative service credit in 1998 using a supplemental data set provided by TRS. The note in Table 1 of Fitzpatrick (2015) states that it was “Based on the author’s calculations using data from Illinois TRS and TSR.” It appears that Fitzpatrick (2015) used the TSR payroll data for service years (her footnote 18 notes that TSR gives ”precise measure of creditable earnings toward the retirement system”.) The data on the AEJ website includes a variable called “trssvc” which we believe measures the estimated years of service of TRS. For some teachers labeled as non-takers this measure is well below 22. If the sample of Fitzpatrick (2015) was selected based on 22-28 years of TSR service, then some teachers whose TRS service years were much lower than the TSR service years would not take the upgrade because the benefit of upgrade before 2009 was too low given how far they were from retirement.

To replicate the calculation of take-up rate by Fitzpatrick (2015), we merged 2014 TSR payroll data and the 2014 TRS teacher information file.[5] There are 122,659 records for the fiscal year 1997-1998 in TSR, and a total of 572,528 records in the TRS teacher information file. Exact match based on name (first name, last name, middle initial) results in 121,855 records, or a matching rate over 99% of the TSR records.

We then match these 121,855 teachers with those in the TRS payroll data. Based on our calculation of TRS service from the TRS payroll data we identify a cohort of 18,875 who had 22-28 TRS service years in 1998. Among these 18,875 teachers 15,951 checked “Yes” for the question “Has 2.2 Upgrade”, which implied a 84.51% take-up rate by 2014.

We also construct an alternative sample from the matched TRS and TSR data by selecting those with service experience in TSR of 22-28 years in 1998. This sample includes 22,121 teachers, among them 14,756 took upgrade by 2014 (based on the “Has 2.2 Upgrade” indicator provided by the 2014 TRS file). So the take-up rate of based on the TSR experience data is a much lower 66.7%.

This exercise replicates the pattern we reported that the sample with 22-28 TSR service years in 1998 has a lower average take-up rate of upgrade than one with 22-28 TRS service years. Because TRS is responsible for administrating pension benefit, we maintain that the TRS service years are more relevant than TSR service years in calculation of benefit for upgrade.

We find evidence that casts doubt on using TSR service years for retirement related calculations. Table 1 of Fitzpatrick (2015) (Figure B1 in this appendix) shows that among 14,431 teachers with 24-28 years of service experience in 1998, 2,079 were not retired by 2009. They would have 35-39 years of service in 2009, assuming teachers earn one service credit per year. (This assumption is supported by the observations that the average annual service credit earned is about 0.97 for full time/part-time teachers in the age group 55-64, based on TRS (2007).) According to the TRS annual actuarial report, the number of active members who have 35-39 years of service as of June 30, 2009 is 1,097 (see page 56 of TRS (2010)). This is consistent with the scenario that the service years of 1998 used in Fitzpatrick (2015) are lower than those of TRS. In comparison, based on our data in Table B21 the non-retired teachers have 35-39 years of service in 2009 is 1,102, very close to the number (1,097) given in the TRS annual actuarial report.

Finally, the 2014 TRS data contain an indicator labeled ”Has 2.2 Upgrade”. The take-up rate of the 22-28 service year cohort in 1998 is 85% by 2014 based on this directly reported indicator.

[4] The take-up rate calculated from Table 1 of Fitzpatrick (2015) is 74%, the take-up rates inferred from discussion through the text of Fitzpatrick (2015) range from 71% to 78%.

[5] The TSR data are from Illinois State Board of Education (ISBE) and can be requested at: `https://www.isbe.net/foia`.

Table B19: Tracking the upgrade decisions and retirement claims, first year of purchase

retirement claims*	whole sample	upgrade by 1998	upgrade by 2000	upgrade by 2006	upgrade by 2008	upgrade by 2014	upgrade by 2019	non-takers by 2019	true non-takers by 2019***
Regular 2.2	7030	6028	6530	6876	6899	6915	6916	114	
2.2 ERO Employer Pay	6593	4982	5628	6433	6445	6446	6446	147	
2.2 ERO Member Pay	2424	1848	2093	2365	2380	2381	2381	43	
Normal - Actuarial calculation	1148	14	19	26	29	31	33	1115	1115
1 2/3% Formula - Graduated	987	13	15	17	18	19	19	968	968
Rule of 85 - 2.2	477	407	435	461	461	461	461	16	
Regular 2.2 - Disability	41	27	32	38	38	39	39	2	
Rule of 85 - Actuarial	8							8	8
ERO Employer Pay	7	1	1	2	2	2	2	5	5
State ERI	7	6	7	7	7	7	7		
ERO Member Pay	5			1	1	1	1	4	4
Rule of 85 - Formula	5							5	5
Age Type Formula Calculation	2			1	1	1	1	1	1
upgrade claims	whole sample	upgrade by 1998	upgrade by 2000	upgrade by 2006	upgrade by 2008	upgrade by 2014	upgrade by 2019	non-takers by 2019	true non-takers by 2019***
summary statistics									
retired by 2014	18734	13326	14760	16227	16281	16303	16306	2428	2106
not retired by 2014	392	12	17	21	21	26	26	366	366
number of teachers with upgrade claim decisions by year	19126	13338	14777	16248	16302	16329	16332	2794	2472
proportion of these teachers over whole sample (i.e., 19126 as denominator)	100.0%	69.74%	77.26%	84.95%	85.23%	85.38%	85.39%	14.61%	12.92%

*Note: Retirement claims need not to be made in the same year of upgrade, but upgrade decisions need to be made before or on retirement claims.
**Note: We track the upgrade decision to 2019 and retirement claim to 2014.
***Note: We remove teachers with five types of retirement claims in the subgroup of "not upgrade by 2019" to build the subgroup of "truly not upgrade by 2019": "Regular 2.2", "2.2 ERO Employer Pay", "2.2 ERO Member Pay", "Rule of 85 - 2.2", and "Regular 2.2 - Disability". These claims are only available to teacher who upgrade.

Table B20: Decomposition of true non-takers by retirement claims*

retirement options	no. obs	age at retirement claim		exp at retirement claim		benefit of upgrade**	
		mean	median	mean	median	mean	median
true non-taker retired	2106	59.74	60.0	35.34	37.0	5.17	0.0
—-1 2/3 % Formula - Graduated	968	59.85	60.0	36.75	37.0	6.05	0.0
—-Normal - Actuarial calculation	1115	59.64	60.0	34.14	36.0	4.27	0.0
—-Others	23			37.84	38.0	0.69	0.0
true non-taker not retired	366					0.00	0.0
total	2472	59.38	60.0	35.75	37.0	4.41	0.0

*Note: See the last column in table B19.

**Note: This is the expected discounted benefit calculated with actual retirement claim in $1,000 2010 dollars.

Table B21: Comparing retirements and upgrades of 2008/2009 with Fitzpatrick(2015), first date of purchase

	Fitzpatrick			Our data				
Year of Experience in 1998	Fraction who retire by 2009	Fraction who upgrade by 2009	Observations	Fraction who retire by 2008	Fraction who upgrade by 2008	Fraction who retire by 2009	Fraction who upgrade by 2009	Observations
22	0.60	0.70	2409	0.33	0.82	0.55	0.82	2385
23	0.67	0.71	2589	0.56	0.82	0.76	0.82	2430
24	0.78	0.76	2991	0.78	0.83	0.86	0.84	2897
25	0.83	0.78	3121	0.87	0.86	0.90	0.86	3006
26	0.88	0.77	2909	0.92	0.87	0.94	0.87	2972
27	0.89	0.74	2674	0.95	0.88	0.96	0.88	2599
28	0.91	0.73	2736	0.96	0.87	0.96	0.87	2837
whole sample	0.73	0.74	19429	0.78	0.85	0.86	0.85	19126

Note: Upgrade and retirement years are recorded by calendar year. Upgrade year is the year of upgrade purchase, retirement year is the year when one makes retirement claim.

Table B22: Comparing retirements and upgrades of 2008/2009 with Fitzpatrick(2015), final date of transaction

	Fitzpatrick			Our data				
Year of Experience in 1998	Fraction who retire by 2009	Fraction who upgrade by 2009	Observations	Fraction who retire by 2008	Fraction who upgrade by 2008	Fraction who retire by 2009	Fraction who upgrade by 2009	Observations
22	0.60	0.70	2,409	0.33	0.29	0.55	0.49	2,385
23	0.67	0.71	2,589	0.56	0.50	0.76	0.68	2,430
24	0.78	0.76	2,991	0.78	0.72	0.86	0.80	2,897
25	0.83	0.78	3,121	0.87	0.82	0.90	0.84	3,006
26	0.88	0.77	2,909	0.92	0.86	0.94	0.87	2,972
27	0.89	0.74	2,674	0.95	0.87	0.96	0.87	2,599
28	0.91	0.73	2,736	0.96	0.87	0.96	0.87	2,837
whole sample	0.73	0.74	19,429	0.78	0.72	0.86	0.78	19,126

Note: The final date of transaction is the date directly available in TRS. The reported cumulative take-up rate by the year is likely lower than the true take-up rate.

C Derivation of OLS of a linear probability model on simulated data with the WTP of unity

Teacher i upgrades ($D_i = 1$) if the benefit $B_i > P_i$ and chooses $D_i = 0$ otherwise, ($i = 1, ..N$). Denote $Q_i = \beta_0 + \beta_1 P_i + \beta_2 B_i$. The OLS minimizes the sum of squared residuals (SSR)

$$min_{\{\beta_0,\beta_1,\beta_2\}} \sum_{i=1}^{N} SSR(Q_i) = \sum_{B_i \geq P_i} (1 - Q_i)^2 + \sum_{B_i < P_i} Q_i^2.$$

The first order condition with respect to β_k ($k = 0, 1, 2$) is

$$\sum_{i=1}^{N} Q_i \frac{\partial Q_i}{\partial \beta_k} = \sum_{B_i \geq P_i} \frac{\partial Q_i}{\partial \beta_k},$$

where $\frac{\partial Q_i}{\partial \beta_0} = 1$, $\frac{\partial Q_i}{\partial \beta_1} = P_i$, $\frac{\partial Q_i}{\partial \beta_0} = B_i$.

Denote the average price and benefit as $\bar{P} = \sum_{i=1}^{N} P_i/N$ and $\bar{B} = \sum_{i=1}^{N} B_i/N$. Denote the fraction of takers as $\bar{D} = \sum_{i=1}^{N} D_i/N = \sum_{B_i \geq P_i} 1/N$, and denote $P_\tau = \sum_{B_i \geq P_i} P_i/N$ and $B_\tau = \sum_{B_i \geq P_i} B_i/N$. Denote $\Delta P = P_\tau - \bar{D}\bar{P}$, $\Delta B = B_\tau - \bar{D}\bar{B}$. And $\Gamma = Var(B)Var(P) - [cov(B, P)]^2$.

The first order condition $\frac{\partial \sum_{i=1}^{N} SSR(Q_i)}{\partial \beta_0} = 0$ implies

$$\bar{D} = \beta_0 + \beta_1 \bar{P} + \beta_2 \bar{B}. \tag{2}$$

From $\frac{\partial \sum_{i=1}^{N} SSR(Q_i)}{\partial \beta_1} - \bar{P}\frac{\partial \sum_{i=1}^{N} SSR(Q_i)}{\partial \beta_0} = 0$ and $\frac{\partial \sum_{i=1}^{N} SSR(Q_i)}{\partial \beta_1} - \bar{B}\frac{\partial \sum_{i=1}^{N} SSR(Q_i)}{\partial \beta_0} = 0$ we have

$$\beta_1 var(P) + \beta_2 cov(B, P) = \Delta P, \tag{3}$$

$$\beta_2 var(B) + \beta_1 cov(B, P) = \Delta B. \tag{4}$$

Solving (3), (4), and (2) yields

$$\hat{\beta}_1 = (Var(B)\Delta P - cov(B, P)\Delta B)/\Gamma, \hat{\beta}_2 = (Var(P)\Delta B - cov(B, P)\Delta P)/\Gamma, \hat{\beta}_0 = \bar{D} - \hat{\beta}_1 \bar{P} - \hat{\beta}_2 \bar{B}. \tag{5}$$

Estimates with iid uniformly distributed price and benefit

In the example of infinitely large sample iid uniformly distributed price ans benefit
$P_i \sim U(0, 1)$, $B_i \sim U(0, B_{max})$;
$var(P) = 1/12$, $var(B) = (B_{max})^2/12$, $COV(B, P) = 0$, $\bar{P} = 1/2$, $\bar{B} = B_{max}/2$;
$\bar{D} = \int_0^1 \int_P^{B_{max}} (1/B_{max}) dBdP = 1 - 1/(2B_{max})$;
$P_\tau = \int_0^1 P \int_P^{B_{max}} (1/B_{max}) dBdP = 1/2 - 1/(3B_{max})$, $\Delta P = -1/(12B_{max})$;
$B_\tau = \int_0^1 \int_P^{B_{max}} (B/B_{max}) dBdP + \int_1^{B_{max}} (B/B_{max}) dB = B_{max}/2 - 1/(6B_{max})$, $\Delta B = 1/4 - 1/(6B_{max})$.

Plugging the moments above into formula (5) yields $\hat{\beta}_1 = -1/B_{max}$, $\hat{\beta}_2 = (3B_{max} - 2)/[(B_{max})^3]$, and $\hat{\beta}_0 = 1 - (3B_{max} - 2)/[2(B_{max})^2]$. Note that the formula for $\hat{\beta}_0$ and $-\hat{\beta}_2/\hat{\beta}_1$ implies $-\hat{\beta}_2/\hat{\beta}_1 = 2(1 - \hat{\beta}_0)$. The ratio $-\hat{\beta}_2/\hat{\beta}_1$ equals 1 when $\hat{\beta}_0$ equals 0.5. This occurs when B_{max} is either 1 or 2. When $B_{max} = 1$, $\bar{D} = \hat{\beta}_0 = 0.5$, and $\hat{\beta}_1 = -1, \hat{\beta}_2 = 1$, and thus the ratio $-\hat{\beta}_2/\hat{\beta}_1 = 1$. When $B_{max} = 2$, $\bar{D} = 0.75$, $\hat{\beta}_0 = 0.5$, and $\hat{\beta}_1 = -0.5, \hat{\beta}_2 = 0.5$. So the ratio $-\hat{\beta}_2/\hat{\beta}_1 = 1$ as well.

References

Fitzpatrick, M. D. (2015). How much are public school teachers willing to pay for their retirement benefits? *American Economic Journal: Economic Policy 7*(4), 165–88.

Fitzpatrick, M. D. (2019). Replication data for: How much are public school teachers willing to pay for their retirement benefits? Nashville, TN: American Economic Association [publisher], 2015. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor], 2019-10-13. Available at: www.openicpsr.org/openicpsr/project/114606/version/V1/view.

Fitzpatrick, M. D. and M. F. Lovenheim (2014). Early retirement incentives and student achievement. *American Economic Journal: Economic Policy 6*(3), 120–54.

ISBE (2020). Teacher salary study. Available at: www.isbe.net/Pages/TeacherSalaryStudy.aspx, retrieved 2021-07-19.

TRS (2007). Investigation of demographic and economic experience 2002-2006. Available at: www.trsil.org/sites/default/files/documents/2007%20ExpAnalysisRept.pdf, retrieved 2019-10-25.

TRS (2010). Actuarial valuation and review of pension benefits as of june 30, 2009. Available at: www.trsil.org/financial/actuarial-reports/valuation-reports, retrieved 2020-08-28.

TRS (2018a). Evolution of the TRS benefit structure. Available at: www.trsil.org/Evolution_of_TRS_Benefit_Structure, retrieved 2018-09-19.

TRS (2018b). Tier 1 member guide. Available at: www.trsil.org/members/retired/guide, retrieved 2018-09-09.

TRS (2019). Understanding the 2.2 formula. Available at: www.trsil.org/sites/default/files/documents/BRO19.pdf, retrieved 2019-10-25.