Higher Salaries or Higher Pensions? Inferring Preferences from Teachers' Retirement Behavior *

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Abstract

Many US workers receive a large portion of their lifetime compensation in the form of retirement pensions. How do changes in pensions vis à vis salaries affect labor supply and retirement? This paper examines the retirement responses to a reform that changed salaries and pensions of public school teachers in a staggered fashion. On one hand, the reform lowered older teachers' gross salaries and, in turn, their future pension benefits; on the other it increased employees' contributions to the pension fund, lowering net salaries but leaving pensions unchanged. I use the staggered timing of implementation of these two provisions to estimate bounds to the income and substitution effects of salaries and pensions. These estimates suggest large substitution effects and more moderate income effects. They also indicate that workers are more responsive to changes in salaries than to equally sized changes in pensions. I show evidence in line with two possible explanations for this result: a) a lack of salience/information on pensions, and b) credit constraints. I use the estimated elasticities to evaluate the effect of an alternative budget-saving policy that reduces pensions instead of net salaries. This alternative policy would lead to fewer, older, and lower-quality teachers retiring compared with the actual reform.

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1 Introduction

A large share of US workers receives a sizable portion of their lifetime compensation in the form of retirement pensions. As of 2018, forty percent of all workers and more than 80 percent of public sector employees were entitled to a defined-benefits (DB) pension upon retirement, whose benefits are calculated as a function of the most recent salaries and do not depend on employees' contributions.[1] Pensions of public sector employees represent a sizable share of states' budgets: for example, in 2017 the US spent approximately $40 billion on public school teachers' pensions.[2] Since employees often contribute very little towards these benefits, public pension liabilities are underfunded in almost all states, for a total of almost $500 billion.[3] At the same time, public pensions are often very generous, with replacement rates that can reach 80 percent of a worker's final salary.

In spite of their weight on employees' lifetime compensation and their cost on public budgets, pensions are not usually regarded as the primary tool to attract and motivate workers; personnel policies tend to focus more on wages and salaries. In principle, a generous pension scheme could attract better workers, incentivize effort, and minimize turnover, while at the same time protecting workers from longevity risk (Gustman et al., 1994). At the same time, however, these schemes could create costs and inefficiencies. In the public sector, for example, generous plans are often accompanied by lower salaries relative to occupations requiring similar skills, especially for younger workers (Ehrenberg, 1980). This could have significant effects on the selection into the job.

This tradeoff leads to a question: are salaries and pensions of public sector workers optimally designed, or is there scope to re-structure employees' lifetime compensation in a way that makes workers better off and improves the composition of the workforce? The answer to this question crucially depends on how workers react to changes in salaries and pensions. This paper takes advantage of a reform of public sector employment, which disproportionately affected teachers, to study how changes in pension benefits vis à vis changes in salaries affect workers' retirement behavior and, ultimately, the composition of the workforce. In March of 2011 the Wisconsin state legislature passed Act 10, a budget repair bill aimed at closing a projected $3.6 billion deficit. With this piece of legislation, the state government dramatically changed the way teachers are

[1] Bureau of Labor Statistics, 2018.

[2] Chad Alderman, "How Much Do Teacher Retirement Plans Cost?" available at https://www.teacherpensions.org/blog/how-much-do-teacher-retirement-plans-cost.

[3] Data from Bloomberg and the US Census, 2017.

paid and the way they contribute to the pension fund, with a timing that varied across school districts.

First, the reform raised employees' contributions to their pension plan from zero to 6.0 on average after 2011. The total per-worker contribution remained the same: this increase simply shifted the burden of pension financing from the state onto the employees. Contribution rates are analogous to payroll taxes; since gross salaries did not adjust upwards, this change translated into a 8.3 percent decline in net salaries of all active teachers immediately following Act 10.

Second, Act 10 changed the rules governing collective bargaining. While until 2011 teachers' salaries were negotiated with the union and based solely on seniority and academic credentials, the reform prohibited unions from entering these negotiations and gave districts the freedom to decide on teachers' pay. This change led to a 7.5 percent decline in gross salaries for older teachers who were eligible to retire. Importantly, since pensions benefits of Wisconsin teachers are calculated as a function of the three most recent salary figures, this decline also translated into a 5.8 percent decline in future pension benefits of retirement-eligible teachers.

Notably, the timing of these changes differed across districts. On one side, the pension contribution rate increased (and, subsequently, net salaries fell) starting from 2012 in all districts. On the other side, districts could exercise their freedom over pay setting only after the expiration of their pre-existing collective-bargaining agreements (CBA), whose date differs across districts depending on the electoral cycle. As a result, differences in the timing of the decline in salaries and pensions can be plausibly considered exogenous and can be used to separate the retirement effects of a decline in net salaries (driven by the increase in the contribution rate) from the effects of a simultaneous decline in gross salaries and pensions (driven by the end of collective bargaining over teachers' salaries).

In principle, a decline in net salaries should have an ambiguous effect on retirement: The substitution effect should make workers more likely to retire, whereas the income effect should make them less likely. A decline in pensions should instead have an unambiguously negative effect on retirement. The data show that retirement rose from 15 to 34 percent after Act 10. Event studies that exploit the different timing of changes in net salaries, gross salaries, and pension benefits indicate that approximately 45 percent of this increase can be attributed to the decline in net salaries starting from 2011, whereas 55 percent can be ascribed to the fall in gross salaries and pension benefits after the expiration of districts' CBAs.

Evidence from these event studies suggest that the substitution effect of salaries dominates over the income effect (since retirement increased after the decline in net salaries), and that salaries' substitution effect dominates over pensions' income and substitution effects (since retirement continued to increase after the expiration of the CBAs). To precisely quantify how teachers value different forms of compensation, I use a lifecycle model. In the model, a worker chooses consumption and leisure (i.e., retirement) to maximize her lifetime utility, subject to an intertemporal budget constraint which depends on net salaries and pension benefits. The solution of this maximization problem yields a retirement demand function, which expresses retirement as a function of current and future salaries and pensions. The retirement function can also be used to map income and substitution effects to the retirement elasticities to salaries and pensions, which can be estimated in the data.

Exploiting the exogenous changes in salaries and pensions introduced by Act 10, I estimate a semi-elasticity of net salaries equal to -2.2; in other words, a one-percent decline in net salaries leads to a 2.2 percentage points, or 13 percent, increase in retirement rates. This estimate can be used to derive a lower bound on the magnitude of the elasticity of intertemporal substitution of salaries, equal to -10.5. I also estimate a pension semi-elasticity equal to 0.6, which implies that a one-percent decline in pensions leads to a 3.5 percent increase in retirement rates. This estimate can be used to derive an upper bound to the income elasticity of pensions, equal to 3.2.

Taken together, these estimated elasticities reveal large substitution effects and a somewhat more muted income effect. Importantly, they also indicate that teachers are more responsive to changes in net salaries than they are to equally-sized changes in retirement benefits. Why is this the case? I explore, and find evidence in support of, two possible explanations. The first is the lack of information or salience over pensions: I show that teachers with a larger share of colleagues who retire, and who are more likely to be exposed to information on pensions, are more responsive to changes in this variable. The second is credit constraints: I show that teachers living and teaching in areas where house prices increased in the previous year, and who are thus more likely to have faced a positive wealth shock, are more responsive. A third possible explanation is uncertainty over the solvency of the pension system; I show, however, that Wisconsin teachers' pension plan has been almost fully funded since 2001, which makes this explanation less compelling.

Taken together, these results suggests that, even for active workers who are close enough to the retirement margin, a change in current compensation is more salient (or valued differently) than a change in future retirement benefits. This finding has important implications for the design of teachers' compensation schemes: If teachers respond differently to these two forms of compensation, shifting part of their lifetime compensation away from retirement towards employment (i.e., raising salaries and making pensions less generous) could have significant effects on teachers' retirement decisions and, in turn, on the composition of the teaching workforce. To test this hypothesis, in the last part of the paper I use estimates of the elasticities to net salaries and pensions to simulate the retirement effects of an alternative budget-cutting policy which would reduce the state's budget by the same amount as Act 10 did, but through a reduction in pensions' replacement rates instead of an increase in employees' contribution rates. I find that, compared with Act 10, this policy would lead to the retirement of fewer, older, and lower-quality teachers. This suggests that anticipating part of teachers' lifetime compensation to when they are active in the labor force could improve the composition of the teaching pool and, as a result, have positive effects on students.

This paper contributes to the existing literature on pensions and on teachers' labor markets in several ways. First, it is one of the few papers to study the effects of simultaneous changes to salaries and pensions on workers' retirement decisions, and among the first to do so for teachers. Most of the existing literature on retirement has focused on the role of social security in shaping the labor supply of older workers (Gustman and Steinmeier, 1986; Rust and Phelan, 1997; French, 2005; Van der Klaauw and Wolpin, 2008; Coile and Gruber, 2007; Mastrobuoni, 2009; Van der Klaauw and Wolpin, 2008; French and Jones, 2011). Pensions are quite distinct from social security: their DB nature is such that there is no direct link between the contributions (if any) that a worker makes to the pension fund throughout his lifetime and the benefits he obtains when he retires, which are a direct function of her salary. As such, the implications of changes in salaries and pensions on welfare and retirement can be very different (Stock and Wise, 1990; Samwick, 1998; Gelber et al., 2016). Furthermore, the combined effects of changes in wages and pensions under a DB plan can be substantially distinct from those under a defined-contribution regime, due to the trade-off between salaries and pensions that DB plans create (Ehrenberg, 1980; Schiller and Weiss, 1980; Lazear, 1985).[4] Moreover, in a context in which wages are related to productivity, the relationship between salaries and pensions can dramatically affect the composition of the workforce. This paper quantifies these effects in the labor market of teachers, a

[4]A relationship between wages and the generosity of pension plans has been suggested as early as Ehrenberg (1980). Lazear (1985) analyzed the effects of different types of pension benefits on labor supply, mobility, and retirement, with a partial focus on DB plans.

profession where quality and productivity can be measured using student test scores.

This paper also provides new estimates of the income and substitution effects on labor supply and retirement generated by changes in salaries and pensions. Some of these papers, such as Costa (1995), Fetter and Lockwood (2018), and Gelber et al. (2016) have found significant income effects and, in the case of Gelber et al. (2016), negligible substitution effects of changes in pension benefits; other works, such as Manoli and Weber (2016), have instead unveiled much larger substitution effects. I contribute to this literature by exploiting contemporaneous and exogenous changes in salaries and pension benefits to simultaneously estimate bounds to both income and substitution effects, and by providing evidence of a differential labor supply response to the same change in salaries and in benefits.

Finally, this paper adds to the limited literature on the role of retirement pensions on teachers' retirement behavior, and provides novel evidence on teachers' preferences for higher salaries relative to higher pensions. Furgeson et al. (2006), Costrell and McGee (2010), Brown (2013), and Ni and Podgursky (2016) exploit different types of changes in retirement benefits to study the relationship between pensions and retirement; these works, however, focus on pension benefits and do not attempt to establish a tradeoff between compensation while active and while retired. In an exercise similar to the one I perform, Fitzpatrick (2015) estimates teachers' willingness to pay for pensions by studying their choices when given the opportunity to purchase additional pensions. While the estimates of Fitzpatrick (2015) are only informative of teachers' valuation of the marginal additional dollar of pensions, which is likely to constitute a lower bound for the average value of pensions to teachers, my estimates permit the identification of the retirement elasticities to salaries and pensions, sufficient statistics for teachers' preferences. On one side, these elasticities can be used to construct bounds on the income and substitution effects of changes in salaries and pensions on retirement, and to establish a tradeoff between these two forms of compensation. On the other, the sufficient statistics allow me to study the effects of counterfactual policies on teachers' behavior.

The rest of the paper proceeds as follows. Section 2 describes salaries and pensions for public school teachers in Wisconsin, a well as the policy changes introduced by Act 10. Section 3 describes the data. Section 4 illustrates how salaries and pension benefits changed in the aftermath of Act 10, and Section 5 describes the retirement responses to these changes across districts. Section 6 presents a lifecycle model and the estimates of the associated retirement elasticities, and Section 7 uses these estimates to simulate the retirement effects of an alternative budget-cutting policy. Section 8 concludes.

2 Salaries and Pensions for Wisconsin's Public School Teachers

2.1 Salaries

As in many US states, salaries of public schools teachers in Wisconsin were determined using salary schedules until 2011. These schedules were part of each district's collective bargaining agreement (CBA), a contract negotiated every two years between each school district and its teachers' union.[5] A salary schedule specifies the salary of each teacher as a function of on her years of seniority and highest education (Podgursky, 2006). Increases in seniority and the acquisition of academic qualifications are associated with an increase in salaries, through movements along the steps and lanes of the schedule. As a result, until 2011 seniority and education were the only determinants of a teacher's pay, with no scope for negotiations between the school district and the individual teachers.

2.2 Pensions

Wisconsin teachers are not eligible to receive Social Security benefits.[6] Upon retirement, "vested" (i.e. eligible) teachers receive a DB pension, paid out of the Wisconsin Retirement System (WRS). In order to become vested, teachers must have at least five years of service, and teachers can retire starting from age 55.

Monthly pension benefits (B) are calculated as a function of each teacher's final average earnings (an average for the 3 highest annual salaries, $\bar{W}$), years of service (s), and incorporate an actuarial reduction for early retirement, function of age a and seniority ($\pi(a, s)$), as well as a "formula multiplier" r, equal to 1.6 percent.[7] Benefits are capped to 75 percent of final average earnings. The formula is as follows:

$$B = \min\{\bar{W}/12 * s * \pi(a, s) * r, 0.75\bar{W}\}$$

[5] In states that allow collective bargaining for public sector employees, these schedules are typically negotiated between school districts and teacher unions. In states with no collective bargaining, these schedules are instead determined at the state level (e.g. Georgia).

[6] Teachers, as active members of the State Teachers Retirement System or the Milwaukee Teachers Retirement System, had a choice in 1956-57 for Social Security coverage as teachers and elected against such coverage. They remain excluded if in subsequent enrollment opportunities they did not elect to become covered under Social Security (Wisconsin Department of Employee Trust Funds, 2013).

[7] The objective of the WRS pension plan is to provide teachers who retire at a "normal" age (i.e. above 57) and with a full career of public employment (between 25 to 30 years of service) a total retirement income between 50% and 75% of the pre-retirement earnings.

Figure I shows a plot of π by age for teachers with different years of experience. The discount factor can take a minimum value of 0.584 for teachers with 5 years of experience and 55 years of age, and a maximum value of 1, reached by all teachers when they either a) turn 65 or b) reach 30 years of experience and 57 years of age.

The WRS, which provides retirement, disability and death benefits to almost all state and local government employees in Wisconsin, is funded through three sources: employer contributions, employee contributions, and investment earnings.[8] As of 2011, however, 99 percent of pension contributions were made by the employer, i.e. the state and the local governments; teachers were contributing zero to the WRS before Act 10.

2.3 Act 10 (2011): Effects on Salaries and Pensions

On June 29, 2011 the State Legislature passed the Wisconsin Budget Repair Bill. The bill, which came to be known as Act 10, was an attempt to close a projected $3.6 billion deficit through two sets of provisions: a) changes in the rules of collective bargaining for public sector unions, and b) a reduction in benefits for all public sector employees, excluding only firemen and policemen and including teachers.

Limits for Public Sector Unions Act 10 imposed severe limits on the powers and scope of action of all public sector unions, including teachers' unions.[9] First and most importantly, the Act limits the scope of collective bargaining on workers' salaries. In the case of teachers, before Act 10 teacher unions could negotiate the entire salary schedule with each school district. After the Act, however, these negotiations are restricted to base salaries, whose growth is also capped to the rate of inflation. Second, Act 10 requires unions to recertify every year by obtaining the absolute majority of all members' votes in yearly elections. Third, it limits the validity of newly stipulated CBAs to one year; and lastly, it prohibits the automatic collection of union dues from employees' paychecks.[10]

Changes in the rules of collective bargaining deeply affected teachers' salaries. The end of collective bargaining over teachers' salary schedules gave school districts the autonomy to uni-

[8] As of 2016, it holds $85 billion in actuarial assets, and it covers more than 256,000 active public employees (including teachers), as well as 154,000 who are no longer active employees (including retirees).

[9] Union membership dropped by nearly 50 percent in Wisconsin in the 5 years after the passage of Act 10. See D. Belkin and K. Maher, *Wisconsin Unions See Ranks Drop Ahead of Recall Vote*, The Wall Street Journal. Retrieved from https://www.wsj.com/articles/SB10001424052702304821304577436462413999718.

[10] In 26 right-to-work states, including Texas, Florida, and Wisconsin, teachers who choose not to join the union are not required to pay monthly dues, despite being covered by collective-bargaining (CB) agreements. In all other states (including California, New York, and Illinois) non-union teachers are also required to pay a fee to the union as a condition of employment.

laterally decide over teachers' pay. Using information collected from districts' employee handbooks, Biasi (2018) shows that different districts decided to use their flexibility in different ways: As of 2015, approximately half of all districts (122 out of 224 with non-missing handbook information) were still setting pay using a schedule only based on experience and education, whereas the remaining half had discontinued the use of such a schedule. In the latter group, school districts chose to use their flexibility to pay high-quality, young teachers more; in addition, some teachers experienced a significant decline in salary growth. Importantly, these changes also affect pension benefits of teachers close to the retirement margin, because they change the level of pay used to calculate these benefits ($\bar{W}$).

Increases in Teachers' Contributions to Pensions Act 10 also contained provisions aimed at generating cost savings for the state and the school districts. The most important was an increase in employees' contribution to the pension fund. Before 2011, the state (and in the case of teachers, also the school districts) contributed 11.6 percent of a worker's salary toward the pension fund. Act 10 left the total contribution per worker largely unchanged (with small upwards adjustments between 2013 and 2016), but mandated that half of it be paid out of a worker's salary starting from 2012. This increase in employees' contributions has the same effect of a payroll tax: Absent endogenous responses of gross salaries, the effect of this provision was a reduction in net salaries, with no direct effect on gross pay nor pension benefits. Other cost-saving provisions include requirements, for school districts, to decrease their spending on health care and and other types of fringe benefits by choosing cheaper insurance plans.

Differences In Timing The provisions of Act 10 had immediate effect on employees and, in principle, were to be applied starting from the 2011-2012 academic year. All CBAs stipulated between school districts and teachers' unions prior to 2011, however, maintained their validity until their expiration. As a result, any change in gross salaries (and, subsequently, in pension benefits) that followed the end of salary schedules could only take place after the expiration of each district's pre-existing CBA. In addition, the uncertainty surrounding Act 10 influenced many districts to extend their current contracts for one or two years after Act 10.

Due to differences in electoral cycles, the expiration dates of pre-existing CBAs (and of their extensions) varied across districts. Table I illustrates the joint distribution of expiration and extension dates. The majority of school districts (203, or 96 percent) had agreements that expired in 2011, with only five CBAs expiring in 2012 and three in 2013. More variation exists, however, in the expiration dates of the extensions: approximately half of all districts had a CBA agreement that expired in 2011 and chose not to extend it, whereas one-third of all districts extended it until 2012 and 15 percent extended it until 2013.

Cross-district differences in expiration and extension dates, coupled with the sharp timing of the other provisions of Act 10, introduce plausibly random variation in salaries and in pension benefits that is useful for identification. While the introduction of employees' contribution to the pension fund triggered a decline in net salaries already in 2011 in all districts, the change in benefits could only have happened after the expiration of each district's CBA (or of its extension) due to the limits maintained by these agreements. Table II shows that the expiration and extension dates are largely unrelated to districts' observable characteristics.[11] The empirical strategy employed in the rest of the paper exploits the exogenous timing of these changes to study teachers' retirement responses to salaries and pensions.

3 Data and Measurement

The main data set contains demographic and employment information on the population of Wisconsin teachers. I combine these data with information on districts' pre-existing CBAs and with student test scores, used to calculate teacher value-added. Data are reported by academic year, referenced using the calendar year of the spring semester (e.g. 2007 for 2006-07).

Teacher data I draw information on the population of Wisconsin teachers from the *PI-1202 Fall Staff Report - All Staff Files* for the years 2007–2015, employment records made available by the Wisconsin Department of Public Instruction (WDPI). These records contain information on all individuals employed by the WDPI in a given year and include socio-demographic information (such as gender, education, and years of teaching experience), the characteristics of job assignments (such as grade and subject taught, full-time equivalency (FTE) units, and school and district identifiers), and compensation (salary and fringe benefits). I express salaries in 2015 dollars and in FTE units. Unless specified, I restrict my attention to teachers with at least 5 years of experience and aged 55 to 75, i.e., those eligible to retire and immediately receive a pension.[12]

[11] The table shows logit estimates of a regression where the dependent variable equals 1 if a district's CBA expires after 2011 (column 1) or if the district enacted a CBA extension (column 2). The independent variables include student enrollment, the number of teachers, the share of black students and of disadvantaged students, per pupil expenditure, and the district's urbanicity; all these variables are measured in 2011.

[12] I exclude long- and short-term substitute teachers, teaching assistants and other support staff, and contracted employees; salaries for these workers are calculated in different ways from salaries of permanent teachers. Due to evident mistakes in the reporting of salary information, I discard information for teachers in the school district of

Information on districts' CBAs I collected information on districts' pre-Act 10 CBAs from three main sources. The first are districts' pre-Act 10 union contracts, most of which are available online. The second are school boards' meeting minutes from 2011, 2012, and 2013; these documents describe whether each district's CBA was set to expire in 2011, whether an extension was granted, and for how long. The third are local newspaper articles from 2011; many of these articles reported on the negotiations taking place and offered enough information to discern when the district's agreement was slated to expire. Several articles also mentioned that the uncertainty surrounding Act 10 influenced many districts to simply extend their current contracts for one or two years.

Using these three sources, I was able to derive the expiration and extension dates for 211 out of 426 school districts, employing 79 percent of all teachers. When possible I prioritize data from union contracts, complementing it with the other two sources when unavailable. These data are summarized in Table I.

Student-level data I use student-level information on math and reading test scores from the Wisconsin Knowledge and Concepts Examination (WKCE, 2007–2014) and Badger test (2015–2016), for all students in grades 3 through 8, as well as demographic characteristics such as gender, race and ethnicity, socio-economic (SES) status, migration status, English-learner status, and disability.[13] These data are used to construct a measure of teacher quality.

3.1 Measurement: Teacher Value-Added

I measure teacher quality using value-added (VA), defined as the teacher's effect on test scores conditional on other determinants of achievement (such as past test scores, student demographics, and school fixed effects; Hanushek, 1971; Rockoff, 2004; Rivkin et al., 2005; Chetty et al., 2014). VA is usually estimated using datasets containing classroom identifiers, which allow researchers to link teachers to the pupils they taught. Information on students' and teachers' classroom was not maintained by the WDPI before 2017. This implies that I can link a teacher to all the students enrolled in her school and grade in a given year, but not to the specific students she taught.

To obtain a measure of teacher effectiveness in the presence of this data limitation, I use

Kenosha, as well as for those in the school district of Milwaukee for the year 2015.

[13]The WKCE was administered in November of each school year, whereas the Badger test was administered in the spring. To account for this change, I follow Biasi (2018) and, for the years 2007–2014, I assign each student a score equal to the average of the standardized scores for the current and the following year.

the strategy of Biasi (2018, Appendix B), which leverages the identification approach of Rivkin et al. (2005).[14] The intuition for the identification is that, with multiple years of data and in the presence of turnover, teacher switches across schools or grades make it possible to isolate the effect of the individual teacher through a comparison of test scores before and after her arrival in a given grade and school.

Estimates are available for 20,370 teachers of math and reading in grades 4 to 8, including 5,160 teachers eligible for retirement.[15] To parse out changes in effort in response to Act 10, I calculate VA as the average teacher effect for the years 2007–2011.

4 Effects of Act 10 on Teachers' Salaries and Pension Benefits

I begin my empirical analysis by characterizing the changes in salaries and pension benefits of retirement-eligible teachers in the aftermath of Act 10. The reform affected teachers' compensation in two ways. First, it increased employees' contribution to the pension fund from zero to above 5 percent. Second, it deprived unions of the power to negotiate teachers' salary schedules with each school district and gave districts more freedom in setting teacher pay. These two changes affected teachers' salaries and pensions in different ways and at different points in time.

4.1 Increase in Contributions to The Pension Fund and Changes in Net Salaries

Changes in rates of employees' contributions to the pension fund are illustrated in Figure II (dashed line). Before Act 10, teachers' contribution rates were zero and the entire contribution (11.6 percent of a teacher's annual salary) was paid by the employer, i.e., the school district. After Act 10, the burden was gradually shifted from the employer onto the employees: Employees' rates rose to 5.8 percent in 2012, 5.9 percent in 2013, and 7.0 percent in 2015. The total per worker contribution to the pension fund remained unchanged.

Absent changes in gross salaries, an increase in the contribution rate should reduce net pay for all active teachers, like a payroll tax. The general-equilibrium effect of this increase, however, depends on the endogenous responses of gross salaries. In a competitive labor market, salaries should adjust upwards in response to the increase in the contribution rate, and the overall effect

[14] Biasi (2018) use data from New York City (NYC) teachers and students, which include classroom links, to validate this estimator of VA against the standard estimator. While the estimator without the links contains more measurement error, it is a forecast-unbiased signal of standard VA and explains approximately 60% of the total variance in the standard VA.

[15] VA estimates are not available for teachers in high school districts, since standardized test scores are not administered in high school.

on net pay could be much smaller or even zero (see Gruber, 1997; Fullerton and Metcalf, 2002, for example).

To study how net salaries changed after Act 10, I perform an event study in the years surrounding the reform. I estimate:

$$\ln w_{ijt}(1-\tau_t) = \sum_{n=2006}^{2015} \delta_n \mathbb{1}(t=n) + \gamma X_{it} + \theta_j + \alpha t + \varepsilon_{it} \quad (1)$$

where w_{it} is the salary of teacher i working in district j in year t and τ_t is the rate of contribution to the pension fund. A vector of observables X_{it}, which includes indicators for the highest education degree and a quadratic polynomial in experience, controls for differences in salaries across teachers with different characteristics; a vector of district fixed effects θ_j controls for time-constant differences in pay across districts. The term αt is a linear pre-trend to account for the fact that salaries were on an upward time trend in the years leading to Act 10 (see Figure AI); α is estimated using data on the years 2007–2011. Fixing the coefficient δ_{2011} to be zero, estimates of the coefficients δ_n capture the change in conditional net salaries in year n relative to 2011.

Figure II (solid line) shows the point estimates and the 90-percent confidence intervals of the coefficients δ_n. As expected, conditioning on the pre-trend net salaries are flat in the years prior to 2011. After Act 10, however, net pay falls by 8.3 percent in 2012, 9.6 in 2013, and 13.1 in 2015 relative to 2011. Notably, this decline is larger than the increase in the contribution rate τ_t. This suggests that teachers' salaries are not perfectly competitive, since they did not adjust upwards to compensate for the increase in τ_t and instead declined even more.

4.2 End of Salary Schedules, Gross Salaries, and Pension Benefits

What drove this extra decline in net pay? Act 10 eliminated collective bargaining over teachers' seniority-based salary schedules and restricted the scope of bargaining to base pay. Furthermore, it capped the growth in base pay to the rate of inflation.[16] As a result, districts acquired the flexibility to unilaterally set teacher pay. Importantly, however, the CBAs stipulated before Act 10 remained binding until their expiration; as a result, districts could only exercise their flexibility after the expiration of the pre-existing CBAs.

Biasi (2018) shows that this newly acquired flexibility triggered a sizable increase in pay for higher-quality, low-seniority teachers, especially in certain districts. Here, I focus on salaries of older, retirement-eligible teachers and perform an event study in a ten-years window surround-

[16] Act 10 defines the rate of inflation as the percentage change in the Consumer Price Index.

ing the expiration of each district's CBA. I estimate:

$$\ln w_{ijt} = \sum_{n=-5}^{5} \delta_n \mathbb{1}(t - Exp_j = n) + \gamma X_{it} + \theta_j + \alpha t + \varepsilon_{it} \quad (2)$$

where Exp_j is the year of expiration of district j's CBA, and everything else is as before. I normalize the coefficient δ_0 to equal zero.

Figure III (solid line) shows estimates of the coefficients δ_n, which capture the change in salaries n years from the expiration relative to the year of a CBA expiration. Estimates of δ_n are indistinguishable from zero for $n < 0$, indicating that conditional salaries were flat in the years leading to the CBA expiration. Salaries slowly declined after the expiration, reaching a 7.5 percent lower level five years after the expiration of the CBA relative to the year of the expiration.

Effects on Pension Benefits DB pensions of Wisconsin teachers are calculated as a function of gross salaries. As a result, the decline in gross salaries that followed the expiration of districts' CBAs directly affected the expected pension benefits of all the teachers who were eligible to retire after this point. To quantify these effects, I re-estimate equation (2) using the logarithm of expected pension benefits for all retirement-eligible employed teachers in a given year as the dependent variable, calculated using the benefit formula (in this specification, I also control for a quadratic polynomial in age). Estimates of δ_n are shown in dashed series in Figure III. Due to the fall in gross salaries, pension benefits fell by 1.1 percent, 2.2 percent, and 5.8 percent one, two, and five years after the expiration of the CBA agreement, relative to the year of the expiration.

4.3 Gross Pay, Net Pay, and Pension Benefits: Summary and Timing

To summarize the changes in gross and net salaries and in pension benefits following Act 10 and characterize the timing of these changes, I estimate the following equation:

$$\ln y_{ijt} = \delta^{post2011} \mathbb{1}(t > 2011) + \delta^{Exp} \mathbb{1}(t > Exp_j) + \gamma X_{it} + \alpha t + \theta_j + \varepsilon_{it} \quad (3)$$

where y_{ijt} is either the gross salary, the net salary, or the pension benefit of teacher i employed in district j in year t, and everything else is as before. In this specification, the parameter $\delta^{post2011}$ captures the changes in the dependent variable following the passage of Act 10 in 2011 but preceding the expiration of the pre-existing CBAs, relative to the years prior to 2011. The parameter

δ^{Exp} captures instead the change in the dependent variable following the expiration of the CBA in Exp_j relative to the years preceding 2011.

After the passage of Act 10 but preceding the expiration of districts' CBAs, conditional gross salaries fell by 2.1 percent relative to the years before Act 10, possibly due to the cap on salary growth introduced by Act 10 (with an estimate for *after Act 10* equal to -0.021, Table III, column 1, significant at 5 percent). After the expiration of each district's CBA, however, gross salaries declined even more, by 3.4 percent (with an estimate for *after CBA expiration* equal to -0.034, Table III, column 1, significant at 1 percent).

While most of the decline in gross salaries took place after the expiration of districts' CBAs, most of the decline in net salaries happened immediately after Act 10. Estimates of $\delta^{post2011}$ and δ^{Exp} in column 3 of Table III indicate that net salaries fell by 8.1 percent immediately after 2011 (with an estimate for *after Act 10* equal to -0.081, Table III, column 3, significant at 1 percent). This estimate is to be expected, since the rate of contribution to the pension fund increased from zero to 5.8 at the end of 2011. After the expiration of each district's CBA, net salaries declined by an additional 4.1 percent, likely due to the decline in gross salaries estimated in column 1 (with an estimate for *after CBA expiration* equal to -0.041, Table III, column 3, significant at 1 percent).

Consistently with the decline in gross salaries being happening mostly after each CBA's expiration, pensions did not change significantly after 2011, but declined by 1.6 percent on average following the expiration (with an estimate for *after Act 10* equal to -0.007 with a p-value of 0.47, and an estimate for *after CBA expiration* equal to -0.041 with a p-value of 0.036, Table III, column 5).

Changes in salaries and pensions: CBA expiration vs. extension As pre-Act 10 CBAs came to expire, districts had to quickly decide on how to set teacher pay. In an attempt to gain more time, some districts chose to extend the validity of the expired CBAs by one or two years, sometimes with minor changes. To better understand how salaries and pensions changed after the expiration of districts' CBAs and after their extension, in columns 2, 3, and 6 of Table III I re-estimate equation (3) including an indicator δ^{Ext} for years following the expiration of a CBA extension, denoted by Ext_j for district j (I set $Ext_j = Exp_j$ for districts with no extension).

Estimates of δ^{Ext} on gross salaries, net salaries, and pension benefits, shown in columns, 2, 4, and 6 of Table III respectively, indicate that most of the change in salaries and pensions happened after the end of CBA extensions. While all these forms of compensation remained unchanged between the expiration and the end of its extension (with estimates of *after CBA* *expiration* equal to -0.008 with a p-value of 0.45 for gross salaries in column 2, -0.0082 with a p-value of 0.43 for net salaries in column 4, and 0.0054 with a p-value of 0.54 for pension benefits in column 6), gross salaries declined by 3.1 percent after an extension, net salaries declined by 3.9 percent, and pension benefits declined by 2.6 percent (with estimates of *after CBA extension* equal to -0.031 for gross salaries in column 2, -0.039 for net salaries in column 4, and -0.026 for pension benefits in column 6, all significant at 1 percent).

5 Teacher Retirement Following Act 10

How did teachers react to the changes in salaries and future pension benefits introduced by Act 10? I exploit cross-district differences in the timing of these changes to separate the labor supply responses to these two forms of compensation, focusing on retirement as the main choice. A retirement-eligible teacher is defined as retiring if she exits from the pool of Wisconsin public school teachers at the end of a given year.[17]

In theory, an unexpected decline in salaries could affect workers' retirement decisions in two ways. First, a decline in salaries makes working less attractive; this should lead individuals to substitute work with retirement (substitution effect). Second, a permanent decline in salaries lowers lifetime income and wealth; this should lead individuals to consume less of all goods, including retirement (income or wealth effect). Given these two opposite forces, the effect of a decline in salaries on retirement is theoretically ambiguous. A decline in pensions, on the other hand, triggers income and substitution effects of the same sign: retirement is less attractive compared to working, which should lower the retirement rate, and lifetime income is lower, which should lower the consumption of all goods. As a result, the effect of a decline in pensions on retirement should unambiguously be positive.

5.1 Retirement Responses to Changes in Salaries and Pensions

Act 10 was followed by a spike in exit rates of retirement-eligible teachers, from 15 percent in 2010 to 33.7 percent in 2011 (a 1.2-fold increase, Figure V, solid line), 21.4 percent in 2012, and 21.4 percent in 2015. Exit rates increased considerably less for teachers aged 50 to 54 (i.e. close to the minimum retirement age of 55, but still not eligible to a pension), from 2.6 percent in 2010

[17] Blundell et al. (2016) explains that the most common retirement transition is from full-time work to no work at all, and that nost of the variability of labor supply is on the margin of whether or not to work, rather than in the number of hours conditional on working (see, Chang and Kim, 2006; Ljungqvist and Sargent, 2014; Rogerson and Wallenius, 2009; Chetty et al., 2011; Erosa et al., 2016, for example).

to 3.1 in 2011, 3.4 in 2012, and 6.0 in 2015 (Figure V, dashed line).

To decompose the spike in retirement following the passage of Act 10 into a response to changes in net pay and a response to changes in future pension benefits, I exploit cross-district differences in the timing of these changes driven by the staggered expiration of districts' pre-Act 10 CBAs. The intuition behind the identification strategy is the following. Since net pay declined at the end of 2011 in all districts due to the increase in the contribution rate, but the change in gross salaries (and, in turn, pension benefits) only happened after each district's CBA expiration, any increase in retirement following the passage of Act 10 but preceding a CBA expiration can be attributed to a decline in net salaries, while any retirement following a CBA expiration can be attributed to the combined decline in salaries and pension benefits.

Identification Assumptions. This identification strategy relies on three strong assumptions. The first is that, in the absence of any changes in salaries or pensions, retirement rates would have remained at their pre-Act 10 levels. This implies that the changes in salaries and pensions introduced by the reform were the unique drivers of the observed spike in retirement. Act 10, however, was a large and controversial reform package. First, it was perceived by many as a direct attack to teachers (Davey and Greenhouse, 2011) and it led to protests and unrest in Madison and in the rest of the state.[18] If a disapproval for the reform made teachers more likely to leave, attributing the post-Act 10 increase in retirement to the decline in net pay due to the increase in the pension contribution would likely overstate teachers' response to the change in net salaries. To account for this issue I include an indicator for the year 2011 in all my empirical specifications; to the extent that upset teachers left right after the passage of the reform, this helps accounting for any increase in retirement driven by teachers' negative attitude towards Act 10. Second, the reform changed health care plans offered to teachers; districts were compelled to find cheaper plans, with possibly different quality. I account for this by controlling for districts' per teacher expenditure on health care and other benefits in each year.

The second assumption is that teachers responded immediately to the changes in pay. This assumption could be violated if teachers learnt about the changes in salaries and pensions with some delay or if they were slower to respond to these changes. As mentioned above, however, the passage of Act 10 and the changes it introduced were extremely salient to the public. This is confirmed by the fact that Google searches of terms related to Act 10, such as "collective

[18] Kim Anderson, director of government relations for the National Educators Association, defined Act 10 as "one of the worst attacks on workers' rights and their voices in the workplace that we've ever seen." *The New York Times*, February 16, 2011.

bargaining," "unions," "pensions," and "contributions," soared in Wisconsin in February 2011 (Figure AII).

The third assumption is that teachers did not anticipate the changes in salaries and pensions introduced by Act 10. While the passage of Act 10 was uncertain until the end,it is possible that teachers in districts with CBAs expiring in 2012 or 2013 were aware of the possibility of a future drop in salaries and pensions already in 2011 and, as a result, left before the CBA expiration. This would lead to incorrectly attribute part of the post-Act 10, pre-CBA expiration increase in retirement to the decline in net salaries instead of the decline in gross salaries and pensions. As I show in the next subsection, however, the data do not show strong evidence in support of this: The spike of retirement rates in each district happens after the expiration of a CBA, and not before.

5.2 Retirement Responses to Changes in Net Salaries

To separate teachers' retirement responses to the drop in net salaries (caused by the increase in the contribution rate) from the decline in gross salaries and pension benefits (triggered by the expiration of districts' CBAs), I perform an event study of retirement rates in a ten-years window around the passage of Act 10 in 2011. I estimate:

$$e_{ijt} = \sum_{n=2008}^{2016} \delta_n \mathbb{1}(t = n) + \gamma X_{it} + \zeta Z_{jt} + \sum_{n=2007}^{2016} \eta_n \mathbb{1}(n > Exp_j) + \theta_j + \varepsilon_{ijt} \tag{4}$$

where e_{ijt} equals one if teacher i retires from district j at the end of year t. The vector X_{it} includes an indicator for gender and quadratic polynomials in age and experience, to account for the effect of these variables on teachers' retirement behavior. The vector Z_{jt} controls for district j's per teacher expenditure on salaries and retirement, health care, and other benefits in year t. The variable Exp_j is the year of expiration of district j's CBA, and the vector θ_j contains district fixed effects. The term $\sum_{n=2008}^{2016} \eta_n \mathbb{1}(n > Exp_j)$ controls for the direct effects of the expiration of CBAs on retirement. Normalizing the coefficient δ_{2010} to zero, the coefficients δ_n in this equation capture the differences in retirement rates between year n and 2010 driven exclusively by the decline in net pay caused by the increase in the contribution rate.

For illustrative purposes, I first estimate δ_n imposing $\eta_n = \zeta = 0$, i.e., not controlling for the expiration of a CBA nor for possible changes in districts' expenditures following Act 10. In this specification, estimates of δ_n conflate the responses to changes in salaries and in pensions.

These estimates, shown in the dashed series in Figure VI, indicate that teacher retirement soared after the passage of Act 10, by a large 17.8 percentage points (or 106 percent relative to a pre-2011 mean retirement of 0.17) in 2011, 6.8 percentage points in 2012, and 7.5 percentage points in 2015 relative to 2010.

Figure VI shows instead estimates of δ_n controlling for the expiration date of districts' CBAs and for district expenditure (i.e., allowing η_t and ζ in equation (4) to be different from zero). These estimates show a smaller, but still large increase in retirement following the passage of Act 10, equal to 8.2 percentage points (or 48 percent) in 2011, 8.6 in 2012, and 12.2 in 2015. Absent any other behavioral responses, these estimates imply that the fall in net pay that followed the increase in the contribution rate caused an increase in retirement for teachers eligible for a pension. This finding in turn suggests that the substitution effect of a change in net pay might have prevailed on the income effect.

5.3 Retirement Responses to Changes in Gross Salaries and Pension Benefits

I now perform the opposite exercise: I isolate the retirement responses to the changes in gross salaries and pension benefits that followed the expiration of CBAs from the responses to the decline in net salaries due to the increase in the contribution rate. To do so I perform an event study of retirement in a nine-years window around the expiration of each district's CBA. I estimate:

$$e_{ijt} = \sum_{n=-4}^{4} \delta_n \mathbb{1}(t - Exp_j = n) + \gamma X_{it} + \zeta Z_{jt} + \theta_j + \eta_0 (t = 2011) + \eta \tau_t + \varepsilon_{ijt} \quad (5)$$

where everything is as before and I normalize the coefficient δ_{-1} to zero. In this specification, the coefficients δ_n capture the change in retirement rates relative to the year before the expiration of a CBA. Importantly, controlling for τ_t allows me to parse out any retirement responses to changes in net salaries driven by changes in the contribution rate, which affected all districts starting from 2011; controlling for $(t = 2011)$ accounts instead for the increase in retirement due to teachers' negative feelings about the reform.

As before, for illustrative purposes I first estimate δ_n constraining η_0, η, and ζ to be zero. These estimates, shown in the solid series in Figure VII, indicate that teacher retirement increased by 16.5 percentage points the year of the CBA expiration, and by 6.4 and 3.9 percentage points one and four years after the expiration.

To isolate the responses to changes in gross salaries and pension benefits, the long-dashed series in Figure VII shows estimates of δ_n controlling for τ_t, an indicator for the year 2011, and district expenditures on other benefits Z_{jt}. Including these controls reduces the estimate for the increase in retirement following a CBA expiration; this estimate, however, remains large at 8.7 percentage points (or 52 percent) the year of the expiration and 10.2 and 8.0 percentage points one and four years after the expiration, respectively.

5.4 Salaries, Pensions, and Retirement: Summary

To summarize teachers' responses to changes in net salaries, gross salaries, and pension benefits, I estimate the following equation:

$$e_{ijt} = \alpha^{2011}\mathbb{1}(t = 2011) + \alpha^{post}\mathbb{1}(t > 2011) + \alpha^{exp}\mathbb{1}(t \geq Exp_j) + \alpha^{ext}\mathbb{1}(t \geq Ext_j) + \gamma X_{it} + \theta_j + \varepsilon_{ijt} \tag{6}$$

Estimates of the parameters α^{2011}, α^{exp}, α^{ext}, and α^{post} in this specification allow to characterize the timing of the retirement responses to the changes introduced after the passage of Act 10. In particular, α^{2011} captures the change in retirement rates in 2011 for districts with agreements expiring after 2011; α^{post} captures the change in retirement rates following 2011 but preceding the expiration of a CBA; α^{exp} and α^{ext} capture the change in retirement rates that followed the expiration of CBAs and of their extension, respectively.

Estimates of these parameters are shown in Table IV. In districts with agreements expiring after 2011, retirement rates increased by 7.8 percentage points in 2011, or 47 percent compared with an average pre-2011 rate of 0.17 (with an estimate of 0.078 for *t = 2011*, Table IV, column 2, significant at 1 percent). After 2011, but before a CBA expiration, retirement rates declined by 5.9 percentage points (with an estimate of *t* > *2011* equal to -0.0592, Table IV, column 2, significant at 1 percent). After the expiration of CBAs and of their extensions, retirement rose again by 9.6 and 1.9 percentage points respectively (with estimates of *t* ≥ *year of CBA exp* and *t* ≥ *year of CBA ext* equal to 0.0955 and 0.0188 respectively, Table IV, column 2, p-values equal to <0.001 and 0.16). These estimates are robust to controlling for age and experience fixed effects (Table IV, column 3).

What do these estimates tell us about income and substitution effects? Recall that a decline in pensions should lead to a *decline* in retirement, whereas a decline in gross pay has a theoretically ambiguous effect. The fact that a simultaneous decline in salaries and pensions led to a large increase in retirement indicates that the substitution effect of salaries dominates over a) the income effect of salaries, and b) the income and substitution effects of pensions, which would push retirement in the opposite direction. This finding provides a first piece of evidence in line with large substitution effects of salaries and a stronger response to changes in salaries than to changes in pensions.

6 Retirement In a Life-Cycle Model

Reduced-form evidence on the effects of Act 10 reveals large and potentially different retirement responses to changes in salaries and pensions. To precisely quantify these responses, however, one must account for the different ways in which the reform affected compensation of teachers in different districts and with different ages and experience levels. In this section I present a simple life-cycle model to illustrate the relationship between retirement and these two forms of compensation. The model provides a theoretical grounding for the estimation of the retirement elasticities to salaries and pensions and of bounds to the income and substitution effects. The model can also be used as a framework to study the effects of alternative policies on salaries and pensions on the composition of the teaching workforce.

6.1 Framework

The standard framework follows the multiperiod single-agent model of labor supply illustrated by Blundell and MaCurdy (1999). Each worker maximizes a time-separable utility which depends on consumption C_{it} (whose price is normalized to 1), leisure L_{it}, and observable factors X_{it}, by choosing consumption and leisure subject to an intertemporal budget constraint. Differently from Blundell and MaCurdy (1999), I assume that the decision on leisure is binary: $L_{it} = 0$ if the individual works (earning an annual salary W_{it} and paying a pension contribution τ_t), and $L_{it} = 1$ if the individual is retired (receiving an annual benefit B_{it}). If the individual does not retire in t, her future pension benefits marginally increase by $\mu(B_{it}, X_{it})$. I also assume that retirement is an absorbing state: if $L_{it} = 1$, then $L_{is} = 1\ \forall s > t$. Individuals discount the future at a rate β and live until period T.

The utility maximization problem of individual i can be expressed as follows (I omit the subscript i for convenience):

$$\max_{\{C_s,L_s\}_{s=t}^{T}} \quad U(t) = \sum_{s=t}^{T} \beta^{s-t} U(C_s, L_s, X_s) \tag{7}$$

$$\text{s. t.} \quad \frac{A_{t+1}}{1+r} = A_t + [W_t(1-\tau_t) + \mu(B_t, X_{it})](1-L_t) + B_t L_t - C_t \tag{8}$$

where A_t are asset holdings at the beginning of period t.

It is useful to rewrite the budget constraint in (8) as follows:

$$C_t + [W_t(1-\tau_t) + \mu(B_t, X_{it}) - B_t]L_t = \frac{A_{t+1}}{1+r_t} - A_t + W_t(1-\tau_t)$$

The left-hand side of this equation shows total expenditure on consumption and leisure, i.e., retirement; when the price of consumption is normalized to 1, the price of retirement is $W_t(1-\tau_t) + \mu(B_t, X_{it}) - B_t$, which I denote by P_t^r. The right-hand side shows instead the individual's "full income" as defined by Blundell and MaCurdy (1999).

The first-order conditions of the problem allow me to express the retirement probability with the following demand function:

$$L_t = L(W_t(1-\tau_t) + \mu(B_t, X_{it}) - B_t, \lambda_t, X_t) \tag{9}$$

The first argument of the function, $W_t(1-\tau_t) + \mu(X_{it}) - B_t$, represents the price of retirement P_t^r and captures the value of working in t, relative to retiring. The second argument, λ_t, is the Lagrange multiplier on the budget constraint, and it represents the marginal utility of wealth. The multiplier is the only element of the model that allows future realizations of salaries and pensions to affect consumption and retirement decisions in t. This multiplier can be expressed as follows:

$$\lambda_t = \Lambda(\{W_s(1-\tau_s)\}_{s\geq t}, \{B_s(1-\tau_s)\}_{s\geq t}, X_t) \tag{10}$$

6.2 Income and Substitution Elasticities

The income and substitution effects of salaries and pensions can be highlighted using equations (9) and (10). The substitution effects of salaries and pensions represent the effects of a change in these variables on retirement, which operates only through a change in the price of leisure P_t^r on L_t. It is useful to define the corresponding substitution (or Frisch) elasticities as follows:

$$
\begin{aligned}
\varepsilon_t^W &= \frac{\partial L_t}{\partial P_t^r}\frac{\partial P_t^r}{\partial W_t(1-\tau_t)}\frac{W_t(1-\tau_t)}{L_t} = \frac{\partial L_t}{\partial P_t^r}\frac{W_t(1-\tau_t)}{L_t} && (11)\\
\varepsilon_t^B &= \frac{\partial L_t}{\partial P_t^r}\frac{\partial P_t^r}{\partial B_t}\frac{B_t}{L_t} = \frac{\partial L_t}{\partial P_t^r}\frac{B_t}{L_t}(\mu_B' - 1) && (12)
\end{aligned}
$$

If retirement is an ordinary good and $\mu_B' < 0$,[19], $\varepsilon_t^W \leq 0$ and $\varepsilon_t^B \geq 0$.

By the same token, the income effects of salaries and pensions represent the effects of changes in these two variables on retirement, which operate only through changes in λ_t. The corresponding elasticities can be defined as:

$$
\begin{aligned}
\eta_t^W &= \frac{\partial L_t}{\partial \lambda_t}\frac{\partial \lambda_t}{\partial W_t(1-\tau_t)}\frac{W_t(1-\tau_t)}{L_t} && (13)\\
\eta_t^B &= \frac{\partial L_t}{\partial \lambda_t}\frac{\partial \lambda_t}{\partial B_t}\frac{B_t}{L_t} && (14)
\end{aligned}
$$

If retirement is a normal good (which implies $\frac{\partial L_t}{\partial \lambda_t} > 0$) and the marginal utility of wealth increases with lifetime income (i.e., if $\frac{\partial \lambda_t}{\partial W_t(1-\tau_t)} > 0$ and $\frac{\partial \lambda_t}{\partial B_t)} > 0$), these elasticities should both be positive.

When are individuals indifferent between salaries and pensions? Individuals are perfectly indifferent between one dollar received in the form of salary and the same dollar received in the form of a pension when the following conditions hold:

$$
\begin{aligned}
\frac{W_t(1-\tau_t)}{\varepsilon_t^W} &= \frac{B_t(\mu_B' - 1)}{\varepsilon_t^B} && (15)\\
\frac{W_t(1-\tau_t)}{\eta_t^W}\frac{\partial \lambda_t}{\partial W_t(1-\tau_t)} &= \frac{B_t(\mu_B' - 1)}{\eta_t^B}\frac{\partial \lambda_t}{\partial B_t} && (16)
\end{aligned}
$$

In words, the first condition implies that the substitution effect from a change in P_t^r triggered by a change in $W_t(1-\tau_t)$ should be the same as the substitution effect from a change in P_t^r triggered by a change in B_t. Similarly, the second condition implies that the income effect from a change in λ_t triggered by a change in $W_t(1-\tau_t)$ should be the same as the substitution effect from a change in λ_t triggered by a change in B_t.

[19]This assumption is supported in the data (see Figure I).

6.3 Estimating Bounds to The Income and Substitution Effects

To empirically assess the income and substitution responses to the same changes in salaries and pensions, one needs to estimate the relative income and substitution elasticities. To make progress on estimation, I linearize (9) (I re-introduce the individual subscript i):

$$L_{it} = \tilde{\beta} \ln P_{it}^r + \tilde{\gamma} \ln \lambda_{it} + \tilde{\delta} X_{it} + \tilde{\omega}_{it} \tag{17}$$

where $\tilde{\omega}_{it}$ is a residual component of the retirement probability. In the above equation, $\tilde{\beta}$ captures the substitution effect and $\tilde{\gamma}$ captures the income effect. If all the variables in equation (17) were observed, one could estimate this model and back out the income and substitution elasticities of salaries and pensions. The variable λ_{it}, however, is unobserved. Without any additional assumptions, its functional form is unspecified; furthermore, future salaries and pensions are unknown in t. One way to address this issue would be to assume a functional form for λ_{it} and for the salary and pension processes. Even without these strong assumptions, however, is it possible to estimate *bounds* on the income and substitution effects. To do so, I modify equation (17) as follows:

$$L_{it} = \beta \ln W_{it}(1 - \tau_t) + \gamma \ln B_{it} + \Gamma X_{it} + \omega_{it} \tag{18}$$

In this equation the estimate for the parameter β, if negative, allows me to recover a lower bound to the substitution elasticity of salaries ε^W, equal to

$$\underline{\varepsilon}^W = \frac{\beta}{L_{it}} \tag{19}$$

Similarly, the estimate for the parameter γ, which should be positive, allows me to construct an upper bound to the income elasticity of pensions η^B, equal to

$$\bar{\eta}^B = \frac{\gamma}{L_{it}} \tag{20}$$

Estimates of the parameters β and γ can be obtained exploiting the variation in salaries and pensions generated by Act 10.

Identification A necessary assumption for the consistent estimation of the parameters β and γ in equation (18) is that the unobserved component of retirement ω_t is mean independent of salaries and retirement benefits. Salaries and benefits, however, can be correlated with unobserved individual characteristics that also directly affect retirement, giving rise to an endogeneity problem. I address this issue with an instrumental strategy approach, which exploits exogenous changes in τ_t after 2011 and in W_{it} and B_{it} after each district's CBA expiration, as well as their differential effects for teachers with different ages and experience levels. The first-stage equations of the two-stages least squares (2SLS) estimation is as follows:

$$\ln W_{it}(1-\tau) = \alpha_1^w \ln(1-\tau_t) + \alpha_2^w a_{it} \ln(1-\tau_t) + \alpha_3^w s_{it} \ln(1-\tau_t) + \alpha_4^w \mathbb{1}(t \geq Exp_j) + \alpha_5^w a_{it} \mathbb{1}(t \geq Exp_j) + \alpha_6^w s_{it} \mathbb{1}(t \geq Exp_j) + \Gamma^w X_{it} + \omega_{it}^w \quad (21)$$

$$\ln B_{it} = \alpha_1^b \ln(1-\tau_t) + \alpha_2^b a_{it} \ln(1-\tau_t) + \alpha_3^b s_{it} \ln(1-\tau_t) + \alpha_4^b \mathbb{1}(t \geq Exp_j) + \alpha_5^b a_{it} \mathbb{1}(t \geq Exp_j) + \alpha_6^b s_{it} \mathbb{1}(t \geq Exp_j) + \Gamma^b X_{it} + \omega_{it}^b \quad (22)$$

where a_{it} and s_{it} are the individual's age and experience in t. In estimation, the vector X_{it} contains quadratic polynomials in age and experience, and indicators for gender and for the year 2011; the latter is meant to to account for a potential increase in retirement driven by teachers' negative attitude towards the reform. Estimates of the first-stage equations are shown in Table V. F-statistics larger than 10 indicate that the instruments strongly predict the endogenous variables.

6.3.1 Results

Estimates of β and γ are shown in Table VI. Both OLS and 2SLS estimates of β are negative; this indicates that the substitution effect of salaries prevails over the income effect. The IV estimate of β, equal to -2.150 (Table VI, column 3, significant at 1 percent), is significantly larger than its OLS counterpart (equal to -0.354, Table VI, column 1, significant at 1 percent). This estimate implies that a one-percent reduction in net salaries leads to a 2.2 percentage points increase in retirement, or 13 percent compared with an average pre-2011 retirement rate of 17 percent. Estimates of β can be used to back out a lower bound for the magnitude of the substitution elasticity, using in the formula in (19). This exercise indicates that the salary substitution elasticity of retirement is at least -10.51; in other words, the substitution effect of a one-percent decline in salaries is an increase in retirement rates of at least 10.5 percent (or 1.8 percentage points).

As predicted by the theory, both OLS and IV estimates of γ are positive; the IV estimate, equal to 0.619 (Table VI, column 3, significant at 1 percent) is significantly larger than the OLS (equal to 0.299, Table VI, column 1, significant at 1 percent). This estimate implies that a one-percent decline in pensions leads to a 0.62 percentage points decline in retirement rates, or 3.6 percent compared with the pre-2011 mean of 0.17. Using the formula in (20), this estimate also implies that the magnitude of the income elasticity of pensions is at most 3.02, which in turn indicates that the income effect of a one-percent decline in salaries is at most a 3.02 percent decline in retirement rates (or 0.5 percentage points). All of the estimates are robust to excluding data from the year 2011 (Table VI, column 4).

Taken together, these results indicate that the substitution effects of salaries are relatively large, and possibly larger than the income effects. This result is in partial contrast with Gelber et al. (2016), who find large income effects of a decline in OASI benefits, but in line with Costa (1995) and Fetter and Lockwood (2018).

Different Responses to Salaries and Pensions A comparison of the point estimates for β and γ can be used to compare the substitution responses to salaries and pensions. Equations (15) and (19) imply that the substitution response to pensions is at least as large as the response to the same percentage change in salaries if and only if $-\gamma/\beta \geq B_{it}/W_{it}(1-\tau_t)$. In the data, $B_{it}/W_{it}(1-\tau_t)$ is equal to 0.4 on average and $-\gamma/\beta$ is at most 0.35 (Table VI, column 4). This implies that the substitution response to pensions is smaller to the substitution response to salaries.

Robustness In Table VII I perform some additional robustness checks. In columns 1 and 2 I control for a teacher's total value of fringe benefits, to account for potential responses to changes in health care and other benefits following Act 10. Similarly, in columns 3 and 4 I control for districts' per teacher expenditure on salaries, retirement, health care, and other benefits. Estimates of β and γ are largely unchanged across these specifications.

6.4 Testing Additional Model Predictions

As a further check for the validity of the model, I test here one of its key predictions. Specifically, the model predicts that more "permanent" changes in net salaries should trigger a large income effect, and a smaller magnitude for the estimate of β. I test this prediction in three ways.

Responses to salaries and responses to τ The parameter β in equation (18) conflates the effect of changes in net salaries on retirement driven by changes in gross salaries W_{it} and changes in contribution rates τ_t. If a change in τ_t is perceived to be more permanent than a change in gross salaries W_{it}, it should have a larger income effect and, in turn, yield an estimate of β that is smaller in magnitude. To test for this, in Table VIII I separately estimate the retirement semi-elasticities of changes in W_{it} and $(1-\tau_t)$. As predicted, the IV estimate of $1-\tau_{it}$ is smaller in magnitude, and equal to -2.087, compared with an estimate of -2.276 for W_{it} (Table VIII, column 3, p-values equal to 0.00 and 0.24 respectively).

Responses by value-added Biasi (2018) argues that the end of collective bargaining introduced by Act 10 led to districts paying higher salaries to more highly effective teachers. For this reason, it might be the case that less effective teachers perceived the decline in W_{it} to be more permanent than more effective ones. If this is the case, the income effect of a decline in salaries should be larger, which implies that the magnitude of the estimate for β should be smaller. Table IX shows estimates of β and γ on the subsample of teachers with value-added in the bottom 75 percent of the distribution. As predicted, the IV estimate of β smaller than the baseline of -2.150 in Table VI, and equal to -1.909 (Table IX, column 3, significant at 1 percent).

Responses by age The income effect of a decline in net salaries should be larger for individuals who expect to receive salaries (i.e., expect to continue being active in the labor force) for a longer period of time. If younger individuals expect to be active for longer than older individuals, the income effect of net salaries should be larger for younger workers (and, in turn, the magnitude of the estimate for β should be smaller). I test this hypothesis in Table X and Figure VIII, where I allow β to vary by age. Estimates of β do not vary monotonically with age. Nonetheless, an estimate of -1.406 for individuals aged 58 to 60 (significant at 10 percent) and of -1.842 for individuals aged 65 and older (significant at 1 percent, Table X, column 3) offer some evidence in support of this prediction.

6.5 Possible Explanations For The Smaller Responses To Changes in Pensions

Estimates of the retirement responses to changes in salaries and pensions indicate that teachers respond more vigorously to the a given change in annual salaries than they do to the same percentage change in annual pension benefits. In this subsection I discuss and test some possible explanations for this finding. I focus on three candidates: information/salience, credit constraints, and pension risk.

6.5.1 Information/Salience

The change in pensions introduced by Act 10 was an indirect one; the reform did not directly target pension benefits, but rather reduced gross salaries and this, in turn, reduced future pensions. One possible reason for the lack of a strong response to pensions is that teachers do not understand how pension benefits are calculated, and failed to anticipate the decline in pensions that followed the end of collective bargaining. A change in pensions could also simply be less salient than a change in salaries.

To test this assumption, I exploit a plausibly exogenous source of variation in access to pension information across teachers: their colleagues. Specifically, I test whether the retirement responses to changes in pensions are larger for those teachers who have a large share of colleagues (defined as teaching in their same school in a given year) who either a) are eligible to retire, or b) retire at the end of a given year. The rationale behind this test is that teachers with a large share of retiring colleagues might be exposed to a larger amount of information on pensions, which might make it more likely that a) they know how pensions are calculated, or b) pensions are a more salient form of compensation to them. Since the share of teachers eligible to retire or retiring in a given school is endogenous, I instrument it using the same reform-driven variation used to instrument for salaries and pensions, with a first stage analogous to equation 22.

The results of this test are shown in Table XI. Estimates of γ are equal to 1.714 for teachers who do not have any colleagues who are eligible to retire (coefficient on $\ln B_{it}$, Table XI, column 3, significant at 1 percent), and it increases by 0.07 for each additional 10 percent increase in the share of colleagues who are eligible (coefficient on $\ln B_{it} \times$ *% ret. eligible*, Table XI, column 3, significant at 5 percent). These estimates imply that a one-percent decline in pensions leads to a 1.774 percent decline in retirement for teachers whose share of retirement-eligible colleagues is 10 percent, and to a 2.064 percent decline in retirement for teachers whose share of retirement-eligible colleagues is 50 percent.

The results are even stronger when exploiting variation in the share of colleagues who do retire. Estimates of γ are equal to 0.358 for teachers who do not have any colleagues who retire in a given year (coefficient on $\ln B_{it}$, Table XI, column 4, significant at 1 percent), and it increases by 0.37 for each additional 10 percent increase in the share of colleagues who retire (coefficient on $\ln B_{it}$ *% retiree*, Table XI, column 4, significant at 1 percent). This implies that a one-percent decline in pensions leads to a 0.728 percent decline in retirement for teachers whose share of colleagues who retire is 10 percent, and to a 2.208 percent decline in retirement for teachers whose share of colleagues who retire is 50 percent.

Taken together, these results indicate that exposure to information and salience might play an important role in how teachers respond to changes to these forms of compensation, and that the smaller response to changes in pensions might be attributed to teachers not knowing how pensions are calculated.

6.5.2 Credit Constraints

Another possible explanation for a weak retirement response to changes in pensions is that teachers are liquidity-constrained and they cannot borrow against their future pensions. If this is true, teachers might simply be unable to change their behavior when pensions change.

To test this hypothesis, I investigate how the responses to salaries and pensions differ across teachers facing positive and negative shocks to one of the most prevalent form of wealth: residential real estate. In particular, I use transaction-based annual house price indexes at the 5-digit zip code level for the years 1986 to 2004, published by the Federal Housing Finance Agency (FHFA), to calculate the annual change in house prices in each district and year.[20] I then construct a variable *shock*>0 which equals one for districts and years where house prices increased in the previous period, and zero otherwise. Under the assumption that teachers live in the same district where they teach, this variable is a proxy for a positive shock in credit availability.

The results from this test, shown in Table XII, suggest that credit constraints explain, at least in part, the weak response to pensions. 2SLS estimates of γ are significantly larger for teachers in districts with a positive house price shock, and equal to 0.846 (Table XII, column 4, significant at 1 percent) compared with teachers in districts with a negative shock (0.570, Table XII, column 5, significant at 1 percent; the difference between these two coefficients is equal to 0.348, column 6, significant at 10 percent). This test provides suggestive evidence that access to credit might play a role in explaining the more muted responses to changes in pensions compared to the responses to changes in salaries.

6.6 Pension Risk

A last explanation for the small response to changes in pensions is that teachers face uncertainty over the solvency of the pension fund and, in turn, over the actual receipt of pension benefits in

[20]The construction of these house price indexes is explained in detail in Bogin et al. (2016).

the future. Indeed, Wisconsin state legislature passed Act 10 to close a large projected budget deficit. In spite of this, historical data on the funding ratios of various public pension funds indicates that the WRS has been almost fully-funded between 2001 and 2016 (with a funding ratio of 0.995 in 2005, 0.998 in 2010, and one in 2016, compared with 0.83, 0.74, and 0.72 for other public pension plans in the US, Figure AIV). Because of this, the risk of pension default was presumably lower in Wisconsin compared with other states.

7 Effects of Alternative Salary and Pension Policies on Retirement

Estimates of the elasticities of retirement to salaries and pensions indicate that teachers respond vigorously to changes in these variables. The direction of these responses suggests a larger substitution elasticity a somewhat more muted income effect; this implies that when the "price" of retirement declines – due to either a decline in net salaries or an increase in pension benefits – teachers will be more likely to retire.

Estimates of these elasticities also indicate that teachers are more responsive to changes in net salaries than they are to equally-sized changes in retirement benefits. This suggests that, even for workers who are close to retirement, a change in current compensation is valued differently than a comparable change in future pension benefits.

This last finding has important policy implications. Public school teachers' compensation schemes are designed in a way that backloads pay into the future and after retirement; as a result, teachers receive more generous pensions and lower salaries compared to other professions requiring similar skills (Fitzpatrick, 2015). If teachers respond differently to changes in salaries and changes in pensions, front-loading lifetime compensation (i.e., raising salaries and making pensions less generous) could significantly change teachers' retirement behavior, with possibly important effects on the composition of the teaching workforce.

To test this hypothesis, I consider an alternative budget-cutting policy which would reduce the state's budget by the same amount as Act 10 did in the medium run, achieving these savings through a reduction in pension benefits rather than through a cut in net pay. Using estimates of the income and substitution elasticities to salaries and pensions, I simulate the retirement behavior of different types of teachers under Act 10 and under this alternative policy, and I evaluate the consequences on the composition of the teaching workforce.

7.1 An Alternative Budget-Cutting Policy

To understand how this alternative policy works, it is useful to quantify how much the state of Wisconsin was able to save with the increase in employees' contribution to the pension fund. The solid line in Figure X shows revenues from employees' contributions. From a pre-Act 10 level of zero, these revenues soared to 178 $M in 2012, 180 $M in 2013, and reached 213 $M in 2016.

Consider now an alternative scenario in which employees' contribution rate remains zero, but pensions are made less generous. Recall that pension benefits are calculated using the formula $B_t = \min[0.75 * \bar{W}_t, \pi * s_t * r * \bar{W}_t]$, and that $r = 1.6\%$ in Wisconsin. The alternative policy consists in lowering r. This change reduces the pension returns of an additional dollar of average salaries $\bar{W}_t$; importantly, the returns to one additional year of age or experience (captured by π) are left unchanged.

Figure AIII shows how net salaries of all teachers (including those not eligible to retire) and pension benefits of teachers who retire would differ under this alternative scenario: As of 2015, salaries would be approximately $4,300 higher on average (from $58,857 to $63,151, 7.3 percent) and pension benefits would be $3,300 lower (from $26,481 to $23,192, 12 percent).

Savings Under The Alternative Policy How much would this alternative policy generate in terms of savings? These savings come from two sources. First, with a lower replacement rate pension benefits would be permanently lower for all teachers who retire after 2011. Second, this new policy could lead to lower retirement rates compared with Act 10 (given the income and substitution effects estimated above), lowering the number of teachers who claim a benefit in each year.

To quantify these savings, I start by estimating the retirement rate associated with $\tau_t = 0$ and $r' < r$. I set $r' = 1.4\%$ and denote the associated retirement benefits as B'_t. I then estimate the counterfactual retirement rate as

$$e'_{it} = \hat{\beta} \ln W_{it} + \hat{\gamma} \ln B'_{it} + \hat{\Gamma} X_{it}$$

where $\hat{\beta}$, $\hat{\gamma}$, and $\hat{\Gamma}$ are the estimates of the parameters β and γ in equation (18), obtained using an IV probit estimation procedure to avoid prediction probabilities outside of the $[0, 1]$ range. These estimates are shown in column 1 of Table AI.

Next, I calculate the savings per retirement-eligible worker in a given year associated with the alternative policy as $S_{it} = (B_{it} - B'_t) * e'_{it} + B_{it} * (e_t - e'_{it})$. The first element of this sum represents the savings coming from a decline in r, whereas the second element constitutes the savings coming from the decline in retirement rates. It is also worth noticing that if $e'_{it} < e_{it}$, worker i will retire at some point $t' > t$ in the future, generating savings equal to $B_{it'} - B'_t$.

The solid line in Figure X shows savings from the alternative policy in each year. These savings grow over time, as the "forgone" benefits of teachers who would retire under Act 10 but not under the alternative policy accumulate over time. As of 2015, savings are equal to approximately half the revenues from employees' contributions; a simple extrapolation predicts that savings would match the contributions by the year 2022.

7.2 Retirement Under The Alternative Policy

Figure XI (top-left panel) shows trends in e'_{it}, the counterfactual retirement rate under the alternative policy. In the years before 2011 the actual and predicted retirement rates are almost identical; this indicates that the model does a fair job in predicting retirement before the policy change. Retirement still increases in 2011 under the alternative policy (due to the inclusion, in the model, of an indicator for the year 2011 which captures the increase in retirement driven by the components of Act 10 not strictly related to salaries and pensions), but it is lower starting from 2012, and equal to 14.0 percent in 2012 (compared with 21.1 percent under Act 10).

Composition of The Pool of Retiring Teachers The top-right panel of Figure XI shows average age of teachers who retire under Act 10 and under the alternative policy. After 2011, the average age of retiring teachers is higher under the alternative policy, and equal to 60.1 in 2012 and 2015, compared with 59.6 under Act 10. Average experience of teachers who decide to retire is also higher under the alternative policy, and equal to 27.0 in 2012 and 28.0 in 2015 compared with 26.2 and 25.7 under Act 10 (Figure XI, bottom-left panel).

Lastly, the bottom-right panel of Figure XI shows average value-added of teachers retiring under Act 10 and under the alternative policy. While retirees' value-added slightly increased after Act 10 compared with before (with 0.008 in 2010 and 0.011 in 2013), it declines under the alternative policy, from 0.004 in 2010 to 0.001 in 2013 and -0.001 in 2015.

Taken together, these simulations suggest that the alternative policy led to fewer, older, and lower-quality teachers retiring relative to Act 10.

8 Discussion and Conclusion

Reforms of teacher compensation have been proposed and analyzed as policy tools to attract and retain talented workers to the profession. Most of the attention, however, has been placed on salaries. This is in spite of the fact that teachers, like many other types of workers, receive a large portion of their lifetime compensation in the form of pensions; as a result, both changes in salaries and changes in pensions could affect the composition of the workforce.

This paper compares the retirement responses to changes in salaries and pensions by studying a reform which contemporaneously changed these two forms of compensation for Wisconsin public school teachers in a staggered fashion. Reduced-form evidence on the timing of retirement indicates that teachers respond to a combined decline in net salaries and a decline in net future pension benefits by becoming more likely to retire.

To learn more about teachers' preferences and separately identify income and substitution effects, I use a simple lifecycle model to derive a retirement demand function. This function which links the retirement probability to changes in salaries and pensions. I use the exogenous changes in salaries and pensions triggered by the reform to estimate elasticities of retirement with respect to changes in salaries and pensions and to bound income and substitution effects. A semi-elasticity of retirement with respect to changes in net salaries equal to -2.2 indicates that the substitution effect of salaries dominates over the income effect. This estimate can also be used to derive a bound on the substitution elasticity of salaries, equal to -10.5, which indicates a large substitution effect compared with other estimates in the literature (i.e., Gelber et al., 2016). The semi-elasticity of retirement with respect to changes in pension benefits, on the other hand, is positive and equal to 0.6, which suggests a more muted income effect.

Importantly, these elasticities also indicate that teachers respond relatively more to changes in salaries than to changes pension benefits. I explore three reasons for why this might be the case. First, I find that teachers respond more to changes in pensions if they have more colleagues who retire in a given year, which suggests an important role for the salience of pensions and of information on how these are calculated. Second, teachers in rural areas respond less, which suggests a potentially large role for credit constraints if these teachers have face more difficulties in accessing credit. Third, younger teachers respond less; this might be in line with teachers facing uncertainty over the solvency of the pension system, if younger teachers expect to face this risk for a longer period of time.

The fact that teachers react more strongly to salaries than to pensions has important implications for the design of salary and pension schemes, because it suggests that shifting part of workers' lifetime compensation away from retirement towards employment (i.e., raising salaries and making pensions less generous) could have significant effects on teachers' retirement decisions and, in turn, on the composition of the teaching workforce. To test this hypothesis, in the last part of the paper I use estimates of the elasticities to net salaries and retirement benefits to simulate retirement under an alternative budget-cutting policy, which would reduce the state's budget through a reduction in pensions instead of a cut in net salaries. The results of this simulation show that this alternative policy would lead to the retirement of fewer, older, and lower-quality teachers. This suggests that anticipating part of teachers' lifetime compensation to when they are active in the labor force could improve the composition of the teaching pool and, as a result, have positive effects on students.

It should be noted that the results of this empirical analysis are based on teachers who had already selected into the teaching profession when the reform was passed. As such, they are not necessarily informative of the behavior of new teachers if the changes in salaries and pensions at study affect the selection of workers into the profession. A more detailed study of the effects of changes in pensions on the supply of new teachers is left to future research.

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Tables

Table I: Dates of Expiration of Districts' CBAs and Their Extensions

Year of: Expiration of Extension → Expiration of CBA ↓	2011	2012	2013	2014	Total
2011	104	71	26	2	203
2012	–	4	1	0	5
2013	–	–	3	0	3
Total	104	75	30	2	211

Note: Number of districts by date of expiration of pre-2011 CBA and expiration of an eventual extension, for districts with non-missing information. For districts with no extension, the extension date is set equal to the CBA expiration date.

Table II: District Characteristics and CBA Expiration Dates: Logit, Eependent Variables Equal 1 if CBA Expires After 2011 or if District Has A CBA Extension

	=1 if expiration after 2011	=1 if has extension
	(1)	(2)
student enrollment	-0.0003*	0.0003
	(0.0002)	(0.0013)
nr of teachers enrollment	0.0071*	0.0039
	(0.0042)	(0.0232)
per pupil expenditure ($1,000)	-0.0666	-0.0773*
	(0.0752)	(0.0450)
share black students	7.3853	-3.3810
	(5.1285)	(3.7149)
share disadvantaged students	-0.0548	-0.6880
	(2.6989)	(0.9189)
in suburban area	1.3825	-0.2672
	(1.1904)	(0.5441)
in urban area	0.6536	-2.9223
	(2.2785)	(1.9898)
N	421	421

Note: The table shows logit estimates of a regression where the dependent variable equals 1 if a district's CBA expires after 2011 (column 1) or if the district enacted a CBA extension (column 2). All independent variables are averages at the district level and correspond to the year 2011. Each observation is a school district. Robust standard errors in parentheses. ** ≤ 0.1, ** ≤ 0.05, *** ≤ 0.01.

Table III: Salaries and Pensions in The Aftermath of Act 10. OLS, Dependent Variable is log(gross salary), log(net salary), log(pension benefits)

	Net salary		Gross salary		Pension Benefits	
	(1)	(2)	(3)	(4)	(5)	(6)
after Act 10	-0.0807***	-0.0810***	-0.0213**	-0.0215**	-0.0064	-0.0067
	(0.0093)	(0.0102)	(0.0095)	(0.0102)	(0.0088)	(0.0095)
after CBA expiration	-0.0407***	-0.0082	-0.0335***	-0.0078	-0.0162**	0.0054
	(0.0086)	(0.0104)	(0.0089)	(0.0104)	(0.0077)	(0.0088)
after CBA extension		-0.0395***		-0.0311***		-0.0264***
		(0.0073)		(0.0073)		(0.0030)
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Exp, Exp^2	Yes	Yes	Yes	Yes	Yes	Yes
Master, PhD	Yes	Yes	Yes	Yes	Yes	Yes
Age, Age^2	No	No	No	No	Yes	Yes
Pre-trends	Yes	Yes	Yes	Yes	Yes	Yes
N	74962	74962	74962	74962	74573	74573
Clusters (districts)	211	211	211	211	211	211
R-squared	0.63	0.63	0.59	0.60	0.97	0.97

Note: The dependent variable is the natural logarithm of a teacher's gross salary (columns 1 and 2), salary net of the pension contribution rate (columns 3 and 4), and pension benefits (columns 5 and 6). The variable *after Act 10* equals 1 for years after 2011. The variable *after CBA expiration* equals 1 for years after the expiration of the pre-existing CBA in the teacher's school district. The variable *after CBA extension* equals 1 for years after the expiration of the extension of the district's CBA, for districts with an extension (*after CBA extension* equals *after CBA expiration* for districts without an extension). All specifications include controls for district fixed effects and quadratic polynomials in experience; columns 5 and 6 also include controls for a quadratic polynomial in age. All variables are detrended using a linear trend estimated on the years 2007 to 2010. The sample is restricted to districts with non-missing CBA expiration dates and to retirement-eligible teachers. Standard errors in parentheses are clustered at the district level. $^{**} \leq 0.1$, $^{**} \leq 0.05$, $^{***} \leq 0.01$.

Table IV: Retirement Over Time. OLS, Dependent Variable Equals 1 if A Teacher Retires

	(1)	(2)	(3)
t = 2011	0.0870***	0.0780***	0.0913***
	(0.0156)	(0.0172)	(0.0174)
t > 2011	-0.0604***	-0.0592***	0.0288
	(0.0175)	(0.0182)	(0.0217)
t ≥ year of CBA exp	0.1011***	0.0955***	0.0725***
	(0.0243)	(0.0250)	(0.0175)
t ≥ year of CBA ext	0.0127	0.0188	0.0348
	(0.0134)	(0.0133)	(0.0214)
District FE	Yes	Yes	Yes
Exp, Exp ^{2}	No	Yes	Yes
Age, Age^2	No	Yes	Yes
Gender	No	Yes	Yes
Distr. expenditure	No	No	Yes
Pre-Act10 ret. rate	0.166	0.166	0.156
N	69410	69348	60838
Clusters (districts)	211	211	211
R-squared	0.03	0.08	0.09

Note: The dependent variable equals 1 if a teacher retires at the end of the academic year. The variables *t=2011* and *t>2011* equal 1 for observations relative to the year 2011 and to years following 2011, respectively. The variable $t \geq$ *CBA expiration* equals 1 for years after the expiration of the pre-existing CBA in the teacher's school district (including teh year of the expiration). The variable $t \geq$ *CBA extension* equals 1 for years after the expiration of the extension of the district's CBA, for districts with an extension ($t \geq$ *CBA extension* equals $t \geq$ *CBA expiration* for districts without an extension). All specifications include controls for district fixed effects; column 2 controls for quadratic polynomials in age and experience and for gender, and column 3 controls for age and experience fixed effects and for gender. The sample is restricted to districts with non-missing CBA expiration dates and to retirement-eligible teachers. Standard errors in parentheses are clustered at the district level. ** ≤ 0.1, ** ≤ 0.05, *** ≤ 0.01..

Table V: 2SLS, First Stage Equations

	$\ln(W_{it}(1-\tau_t))$		$\ln(B_{it})$	
	(1)	(2)	(3)	(4)
$\ln(1-\tau_t)$	0.597	0.347	-0.432	-0.713
	(1.394)	(1.425)	(1.008)	(1.023)
Age * $\ln(1-\tau_t)$	0.007	0.012	0.004	0.009
	(0.018)	(0.019)	(0.013)	(0.013)
Experience * $\ln(1-\tau_t)$	-0.051**	-0.051**	-0.041**	-0.042**
	(0.020)	(0.020)	(0.020)	(0.019)
Post CBA expiration	0.176*	0.173*	0.184***	0.182***
	(0.102)	(0.102)	(0.069)	(0.069)
Age * Post CBA expiration	-0.002	-0.002	-0.002**	-0.002**
	(0.001)	(0.001)	(0.001)	(0.001)
Experience * Post CBA expiration	-0.003*	-0.003*	-0.002*	-0.002*
	(0.001)	(0.001)	(0.001)	(0.001)
$t = 2011$	0.051***		0.053***	
	(0.005)		(0.004)	
District FE	Yes	Yes	Yes	Yes
Age, exp FE	Yes	Yes	Yes	Yes
Excl. 2011	No	Yes	No	Yes
F-stat	8.79	11.43	161.89	163.61
N	74687	66043	74306	65679
# clusters (districts)	211	211	211	211

Note: The table shows the first-stage estimates of the 2SLS approach. The dependent variable is the natural logarithm of net salaries (columns 1 and 2) and of pension benefits (columns 3 and 4). The variable τ_t is the pension contribution rate; the variables *Post CBA expiration* and *Post CBA extension* equal 1 for years following each district's CBA expiration or expiration of the extension (if one was adopted), respectively. All specifications include district, age, years of experience, and gender fixed effects, as well as an indicator for the year 2011; columns 2 and 4 exclude observations for the year 2011. The F-statistic refers to a test of joint significance of the variables reported in the table. Standard errors in parentheses are clustered at the district level. $^{**} \leq 0.1$, $^{**} \leq 0.05$, $^{***} \leq 0.01$.

Table VI: Retirement Semi-Elasticities to Salaries and Pensions. OLS and 2SLS, Dependent Variable Equals 1 If A Teacher Retires At The End Of The Year

	OLS		2SLS	
	(1)	(2)	(3)	(4)
$\ln(W_t(1-\tau_t))$	-0.354***	-0.402***	-2.150***	-1.677***
	(0.053)	(0.056)	(0.579)	(0.397)
$\ln B_t$	0.299***	0.332***	0.619***	0.590***
	(0.042)	(0.044)	(0.120)	(0.118)
$t = 2011$	0.152***		0.237***	
	(0.017)		(0.027)	
District FE	Yes	Yes	Yes	Yes
Age, exp FE	Yes	Yes	Yes	Yes
Excl. 2011	No	Yes	No	Yes
$\underline{\varepsilon}^W$	-1.73	-2.17	-10.51	-9.04
$\bar{\eta}^B$	1.46	1.79	3.02	3.18
KP F-stat			7.15	10.30
Hansen J-test (p-value)			0.01	0.06
Pre-Act10 ret. rate	0.17	0.17	0.17	0.17
N	68100	59473	68100	59473
# clusters (districts)	211	211	211	211

Note: The dependent variable equals one if a retirement-eligible teacher exits at the end of the academic year. Columns 1 and 2 estimate OLS; columns 3 and 4 estimate 2SLS, using the first stage in equation (21). The variables W_{it} and τ_t represent the salary and contribution rate for teacher i in year t. The variable B_{it} represents the pension benefit for a teacher i who retires in year t. All specifications include controls for the year 2011, for quadratic polynomials in age and experience, for gender, and for district fixed effects; columns 2 and 4 exclude observations for the year 2011. The table also reports the Kleibergen-Paap Wald F statistic for weak instruments and the p-value of the Hansen J-statistic test for overidentification. Standard errors in parentheses are clustered at the district level. ** ≤ 0.1, ** ≤ 0.05, *** ≤ 0.01.

Table VII: Retirement Semi-Elasticities to Salaries and Pensions: Robustness Checks. OLS and 2SLS, Dependent Variable Equals 1 If A Teacher Retires At The End Of The Year

	2SLS			
	(1)	(2)	(3)	(4)
$\ln(W_t(1-\tau_t))$	-2.989***	-1.697***	-2.726***	-2.096***
	(0.467)	(0.367)	(0.444)	(0.433)
$\ln B_t$	1.070***	0.594***	1.490**	1.621**
	(0.181)	(0.116)	(0.620)	(0.691)
ln fringe benefits	0.266**	0.002		
	(0.109)	(0.078)		
$t = 2011$	0.231***		0.167***	
	(0.028)		(0.034)	
District FE	Yes	Yes	Yes	Yes
Age, exp FE	Yes	Yes	Yes	Yes
Distr. expenditure	No	No	Yes	Yes
Excl. 2011	No	Yes	No	Yes
$\underline{\varepsilon}^W$	-14.63	-9.16	-13.26	-11.43
$\bar{\eta}^B$	5.23	3.20	7.25	8.84
KP F-stat	8.52	10.63	6.10	6.30
Hansen J-test (p-value)			0.01	0.05
Pre-Act10 ret. rate	0.17	0.17	0.16	0.16
N	68030	59427	59616	50989
# clusters (districts)	211	211	211	211

Note: The dependent variable equals one if a retirement-eligible teacher exits at the end of the academic year. Columns 1 and 2 estimate OLS; columns 3 and 4 estimate 2SLS, using the first stage in equation (21). The variables W_{it} and τ_t represent the salary and contribution rate for teacher i in year t. The variable B_{it} represents the pension benefit for a teacher i who retires in year t. The variable *fringe* is a teacher's total fringe benefits. All specifications include controls for the year 2011, for quadratic polynomials in age and experience, for gender, and for district fixed effects; columns 3 and 4 also control for district expenditure on salaries, retirement benefits, health benefits, and other benefits, per teacher. The table also reports the Kleibergen-Paap Wald F statistic for weak instruments and the p-value of the Hansen J-statistic test for overidentification. Standard errors in parentheses are clustered at the district level. ** ≤ 0.1, ** ≤ 0.05, *** ≤ 0.01.

Table VIII: Retirement Semi-Elasticities to Salaries, Contribution Rates, and Pensions. OLS and 2SLS, Dependent Variable Equals 1 If A Teacher Retires At The End Of The Year

	OLS		2SLS	
	(1)	(2)	(3)	(4)
$\ln W_t$	-0.243***	-0.301***	-2.276	-1.906
	(0.078)	(0.080)	(1.919)	(1.923)
$\ln(1-\tau_t)$	-0.761***	-0.735***	-2.087***	-1.584***
	(0.125)	(0.132)	(0.449)	(0.505)
$\ln B_t$	0.175***	0.218***	0.776	0.857
	(0.067)	(0.069)	(1.819)	(1.969)
$t = 2011$	0.164***		0.235***	
	(0.015)		(0.025)	
District FE	Yes	Yes	Yes	Yes
Age, exp FE	Yes	Yes	Yes	Yes
Excl. 2011	No	Yes	No	Yes
ε^W	-1.19	-1.62	-11.12	-10.28
ε^τ	-3.72	-3.96	-10.20	-8.54
$\bar{\eta}^B$	0.85	1.17	3.79	4.62
KP F-stat			8.47	6.53
Pre-Act10 ret. rate	0	0	0	0
N	68100	59473	68100	59473
# clusters (districts)	211	211	211	211

Note: The dependent variable equals one if a retirement-eligible teacher exits at the end of the academic year. Columns 1 and 2 estimate OLS; columns 3 and 4 estimate 2SLS, using the first stage in equation (21). The variables W_{it} and τ_t represent the salary and contribution rate for teacher i in year t. The variable B_{it} represents the pension benefit for a teacher i who retires in year t. All specifications include controls for the year 2011, for quadratic polynomials in age and experience, for gender, and for district fixed effects; columns 2 and 4 exclude observations for the year 2011. The table also reports the Kleibergen-Paap Wald F statistic for weak instruments. Standard errors in parentheses are clustered at the district level. $^{**} \leq 0.1$, $^{**} \leq 0.05$, $^{***} \leq 0.01$.

Table IX: Retirement Semi-Elasticities to Salaries and Pensions for Teachers With Low Value-Added. OLS and 2SLS, Dependent Variable Equals 1 If A Teacher Retires At The End Of The Year

	OLS		2SLS	
	(1)	(2)	(3)	(4)
$\ln(W_t(1-\tau_t))$	-0.373***	-0.416***	-1.909***	-0.859
	(0.098)	(0.098)	(0.653)	(0.570)
$\ln B_t$	0.325***	0.358***	0.725***	0.604***
	(0.086)	(0.085)	(0.135)	(0.113)
$t = 2011$	0.184***		0.251***	
	(0.018)		(0.034)	
District FE	Yes	Yes	Yes	Yes
Age, exp FE	Yes	Yes	Yes	Yes
Excl. 2011	No	Yes	No	Yes
ε^W	-2.12	-2.76	-10.82	-5.69
$\bar{\eta}^B$	1.75	1.93	3.91	3.26
KP F-stat			1.73	2.68
Pre-Act10 ret. rate	0.14	0.14	0.14	0.14
N	10026	8673	10026	8673
# clusters (districts)	209	207	209	207

Note: The dependent variable equals one if a retirement-eligible teacher exits at the end of the academic year. Columns 1 and 2 estimate OLS; columns 3 and 4 estimate 2SLS, using the first stage in equation (21). The variables W_{it} and τ_t represent the salary and contribution rate for teacher i in year t. The variable B_{it} represents the pension benefit for a teacher i who retires in year t. All specifications include controls for the year 2011, for quadratic polynomials in age and experience, for gender, and for district fixed effects; columns 2 and 4 exclude observations for the year 2011. The table also reports the Kleibergen-Paap Wald F statistic for weak instruments. The sample is restricted to teachers in the bottom 75 percent of the value-aded distribution in the state. Standard errors in parentheses are clustered at the district level. $^{**} \leq 0.1$, $^{**} \leq 0.05$, $^{***} \leq 0.01$.

Table X: Retirement Semi-Elasticities to Salaries and Pensions, By Age. OLS and 2SLS, Dependent Variable Equals 1 If A Teacher Retires At The End Of The Year

	OLS		2SLS	
	(1)	(2)	(3)	(4)
$\ln(W_t(1-\tau_t))$ * age $\in [55,57]$	-0.372***	-0.395***	-2.819***	-1.566**
	(0.066)	(0.064)	(0.966)	(0.789)
$\ln(W_t(1-\tau_t))$ * age $\in [58,60]$	-0.318***	-0.355***	-1.406*	-0.939*
	(0.065)	(0.067)	(0.717)	(0.551)
$\ln(W_t(1-\tau_t))$ * age $\in [61,62]$	-0.252***	-0.301***	-2.045***	-1.276*
	(0.079)	(0.080)	(0.656)	(0.686)
$\ln(W_t(1-\tau_t))$ * age $\in [63,65]$	-0.334***	-0.388***	-1.755***	-1.443***
	(0.054)	(0.054)	(0.515)	(0.402)
$\ln[W_t(1-\tau_t)]$ * age > 65	-0.221***	-0.245***	-1.842***	-1.220**
	(0.067)	(0.071)	(0.649)	(0.606)
$\ln B_t$	0.284***	0.302***	0.468***	0.478***
	(0.055)	(0.052)	(0.118)	(0.126)
$t = 2011$	0.163***		0.245***	
	(0.015)		(0.042)	
District FE	Yes	Yes	Yes	Yes
Age, exp FE	Yes	Yes	Yes	Yes
Excl. 2011	No	Yes	No	Yes
$\underline{\varepsilon}^W$, age $\in [55,57]$	-2.42	-2.81	-18.33	-11.12
$\underline{\varepsilon}^W$, age > 65	-1.44	-1.74	-11.98	-8.66
$\bar{\eta}^B$	1.39	1.63	2.29	2.58
KP F-stat			2.40	1.59
Pre-Act10 ret. rate	0.17	0.17	0.17	0.17
N	68100	59473	68100	59473
# clusters (districts)	211	211	211	211

Note: The dependent variable equals one if a retirement-eligible teacher exits at the end of the academic year. Columns 1 and 2 estimate OLS; columns 3 and 4 estimate 2SLS, using the first stage in equation (21). The variables W_{it} and τ_t represent the salary and contribution rate for teacher i in year t. The variable B_{it} represents the pension benefit for a teacher i who retires in year t. The variables *age* $\in [55,57]$, *age* $\in [58,60]$, *age* $\in [61,62]$, *age* $\in [63,65]$, and *age* > 65 equal one for teachers with ages in each of these intervals. All specifications include controls for the year 2011, for quadratic polynomials in age and experience, for gender, and for district fixed effects; columns 2 and 4 exclude observations for the year 2011. The table also reports the Kleibergen-Paap Wald F statistic for weak instruments. Standard errors in parentheses are clustered at the district level. ** ≤ 0.1, ** ≤ 0.05, *** ≤ 0.01.

Table XI: Retirement Semi-Elasticities to Salaries and Pensions, By Exposure to Retirement-Eligible or Retiring Colleagues. OLS and 2SLS, Dependent Variable Equals 1 If A Teacher Retires At The End Of The Year

	OLS		2SLS	
	(1)	(2)	(3)	(4)
% ret. eligible	0.002		-0.042	
	(0.005)		(0.033)	
$\ln(W_t(1-\tau_t))$	-0.433***	-0.427***	-2.732***	-0.573
	(0.053)	(0.051)	(0.853)	(0.448)
$\ln B_t$	0.400***	0.368***	1.714***	0.358***
	(0.047)	(0.044)	(0.351)	(0.073)
$\ln B_t*$ % ret. eligible	-0.000		0.007**	
	(0.000)		(0.003)	
% retirees		-0.067***		-0.317***
		(0.012)		(0.098)
$\ln B_t*$ % retirees		0.008***		0.037***
		(0.001)		(0.010)
District FE	Yes	Yes	Yes	Yes
Age, exp FE	Yes	Yes	Yes	Yes
$\underline{\varepsilon}^W$	-2.12	-2.09	-13.35	-2.80
$\bar{\eta}^B$, 25 pctle	1.95	1.80	8.71	1.75
$\bar{\eta}^B$, 75 pctle	1.94	1.98	9.05	2.64
Pre-Act10 ret. rate	0.17	0.17	0.17	0.17
N	68010	68010	68010	68010
# clusters (districts)	211	211	211	211

Note: The dependent variable equals one if a retirement-eligible teacher exits at the end of the academic year. Columns 1 and 2 estimate OLS; columns 3 and 4 estimate 2SLS, using the first stage in equation (21). The variables W_{it} and τ_t represent the salary and contribution rate for teacher i in year t. The variable B_{it} represents the pension benefit for a teacher i who retires in year t. The variable % *ret. eligible* corresponds to the share of teachers in the school of teacher i at time t who are eligible to retire in that year; the variable % *retirees* corresponds to the share of teachers in the school of teacher i at time t who retire at the end of that year. All specifications include controls for the year 2011, for quadratic polynomials in age and experience, for gender, and for district fixed effects. Standard errors in parentheses are clustered at the district level. ** ≤ 0.1, ** ≤ 0.05, *** ≤ 0.01.

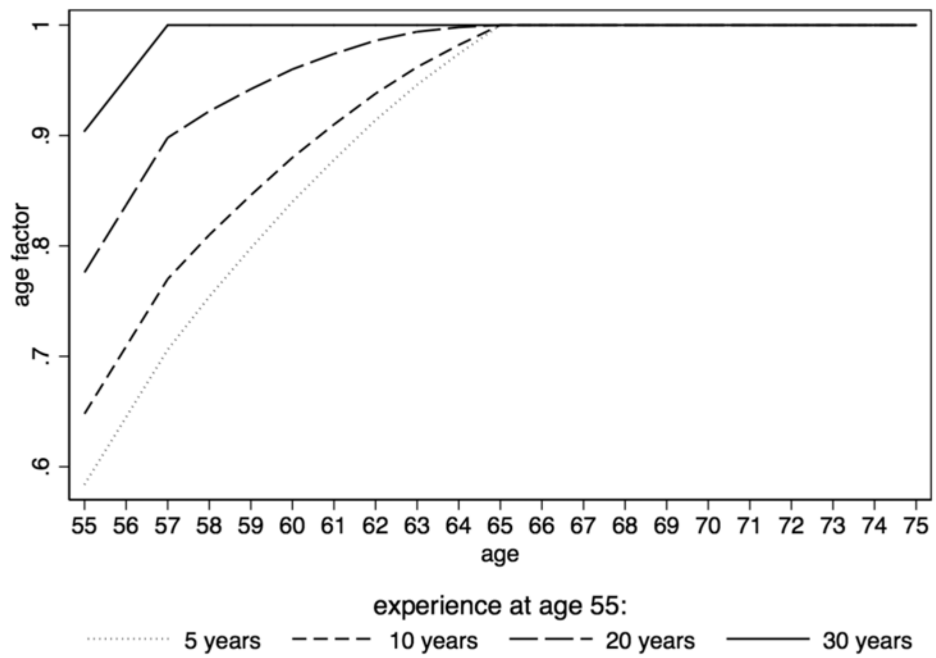
Table XII: Retirement Semi-Elasticities to Salaries and Pensions, By Access to Credit. OLS and 2SLS, Dependent Variable Equals 1 If A Teacher Retires At The End Of The Year

	OLS			2SLS		
	(1) shock > 0	(2) shock < 0	(3)	(4) shock > 0	(5) shock < 0	(6)
$\ln(W_t(1-\tau_t))$	-0.438***	-0.365***	-0.428***	-0.771	-1.243***	-1.315***
	(0.073)	(0.054)	(0.058)	(0.598)	(0.421)	(0.284)
$\ln B_t$	0.408***	0.353***	0.402***	0.846***	0.570***	0.307
	(0.066)	(0.051)	(0.045)	(0.296)	(0.148)	(0.209)
shock > 0			-0.141			-5.105
			(0.391)			(6.513)
$\ln(W_t(1-\tau_t))*$ shock > 0			0.033			0.151
			(0.038)			(0.563)
$\ln B_t*$ shock > 0			-0.022***			0.348*
			(0.006)			(0.183)
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Age, exp FE	Yes	Yes	Yes	Yes	Yes	Yes
$\underline{\varepsilon}^W$	-2.06	-2.01		-3.62	-6.84	
$\underline{\varepsilon}^W$, -shock			-2.13			-6.53
$\underline{\varepsilon}^W$, +shock			-1.96			-5.78
$\bar{\eta}^B$	1.91	1.94		3.97	3.14	
$\bar{\eta}^B$, -shock			2.00			1.53
$\bar{\eta}^B$, +shock			1.89			3.26
Pre-Act10 ret. rate	0.15	0.17	0.16	0.15	0.17	0.16
N	41413	24825	66238	41413	24825	66238
# clusters (districts)	208	207	208	208	207	208

Note: The dependent variable equals one if a retirement-eligible teacher exits at the end of the academic year. Columns 1 and 2 estimate OLS; columns 3 and 4 estimate 2SLS, using the first stage in equation (21). The variables W_{it} and τ_t represent the salary and contribution rate for teacher i in year t. The variable B_{it} represents the pension benefit for a teacher i who retires in year t. The variable *shock* > 0 equals one for teachers in districts where house prices increased in $t-1$ relative to $t-2$. All specifications include controls for the year 2011, for quadratic polynomials in age and experience, for gender, and for district fixed effects. Standard errors in parentheses are clustered at the district level. $^{**} \leq 0.1$, $^{**} \leq 0.05$, $^{***} \leq 0.01$.

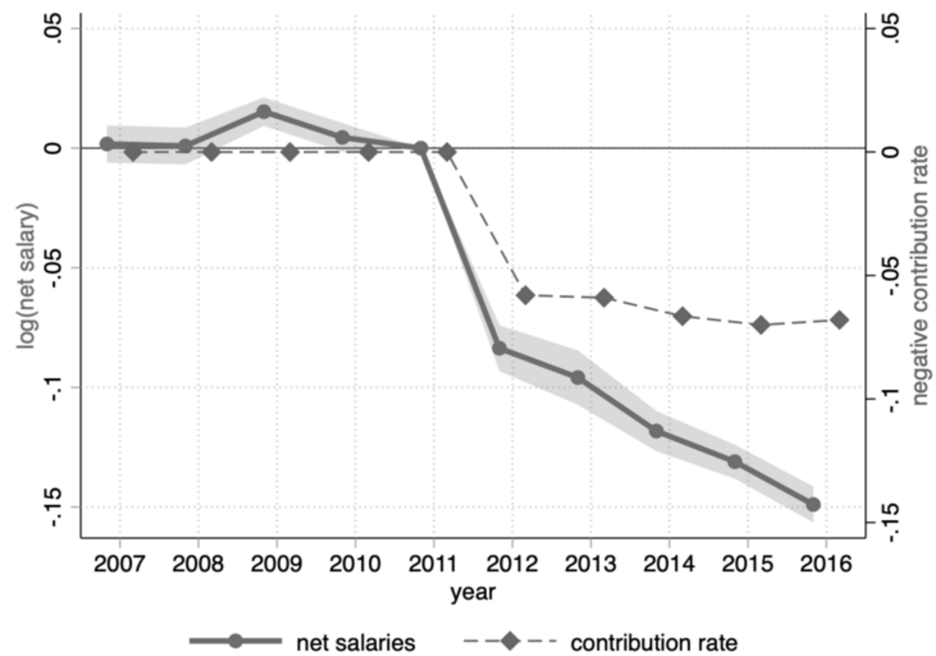
Figures

Figure I: Actuarial Reduction Factor in Teachers' DB Pension Formula



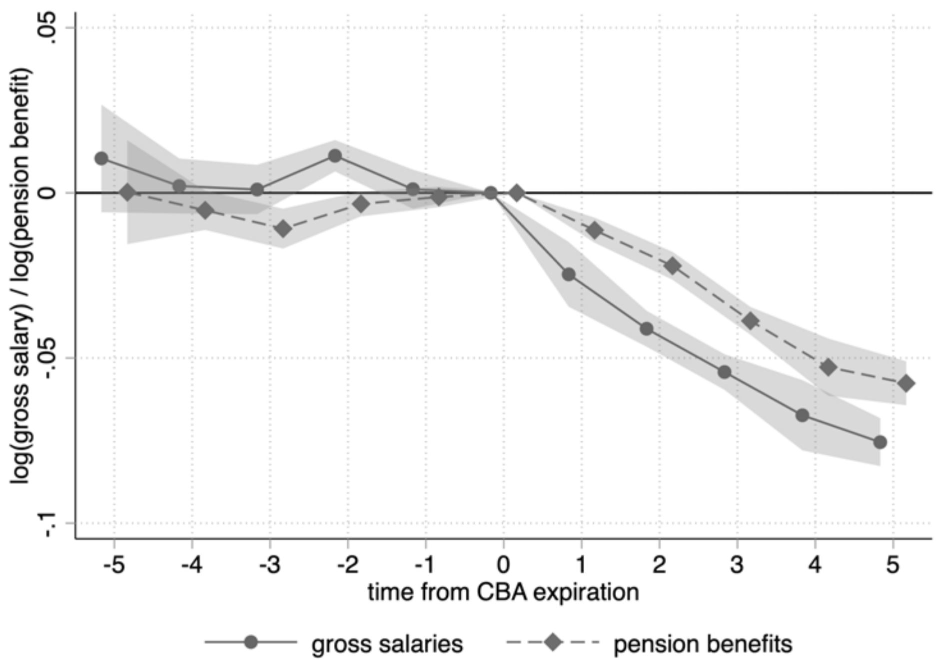
Note: The figure plots the actuarial reduction factor π used in teachers' pension formula, by age and separately for teachers with 5, 10, 20, and 30 years of experience by age 55.

Figure II: Net salaries and pension contribution rates, over time



Note: The solid line shows teachers' salaries, net of contributions to the pension fund, conditional on seniority, education, and district effects and relative to the year 2011. Each point on the line corresponds to the OLS point estimate and the 90 percent confidence interval of each parameter δ_n in the equation $\ln y_{idt} = \sum_{n=2007}^{2016} \delta_n \mathbb{1}(t = n) + \beta X_{it} + \theta_j + \varepsilon_{ijt}$, where y_{idt} is the net salary teacher i working in district j in year t, X_{it} is a vector of years of experience fixed effects interacted with indicators for the highest education degree (Bachelor, Master's, PhD), and θ_j are district fixed effects. The coefficient δ_{2011} is normalized to zero and standard errors are clustered at the district level. The dashed line shows the negative of the rate of contribution to the pension fund for all Wisconsin teachers in a given year.

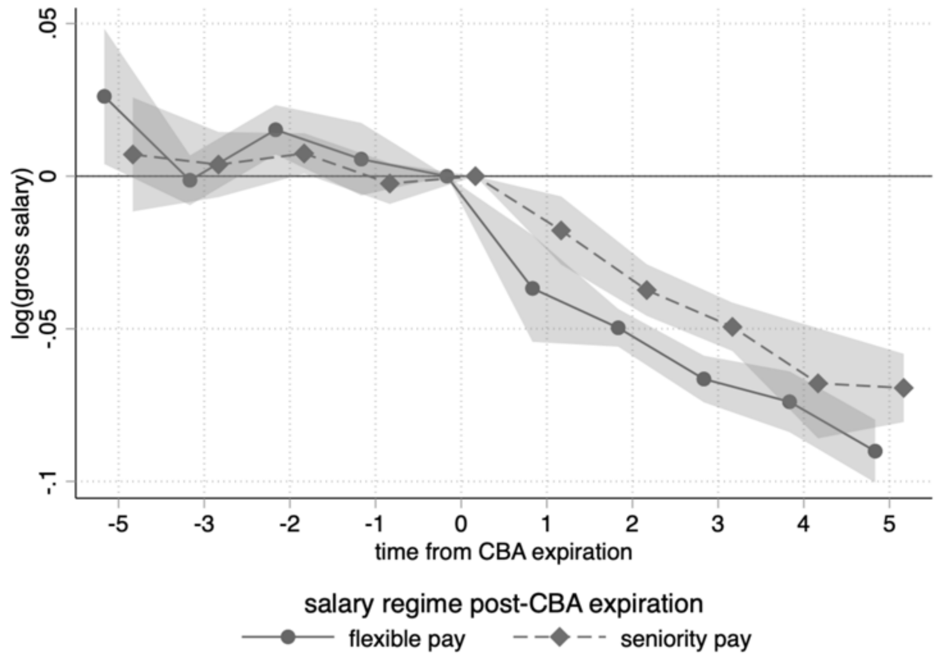
Figure III: Teachers' gross salaries and pension benefits: Event study



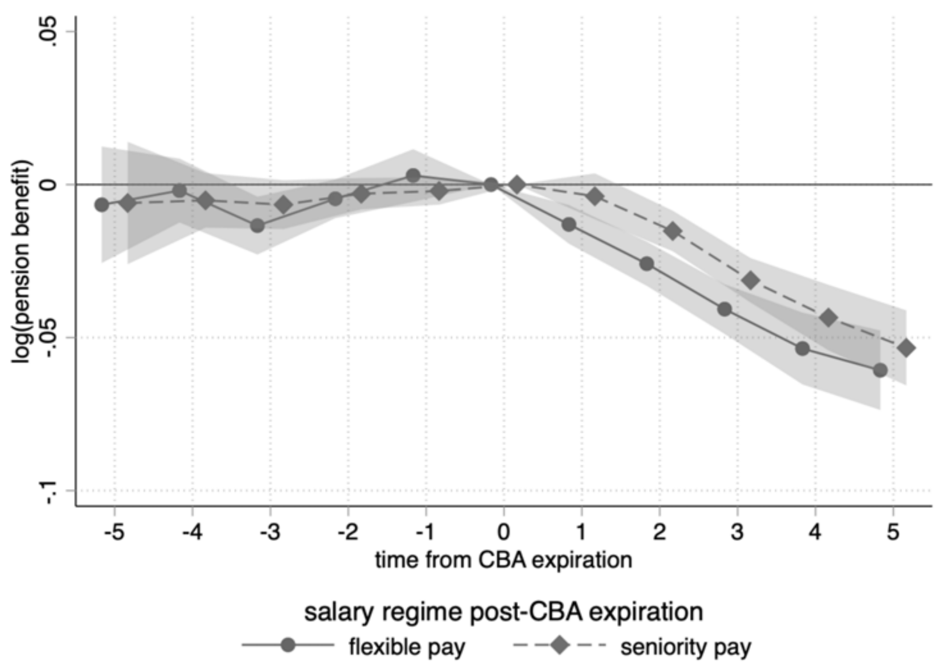
Note: The figure shows an event study of gross salaries (solid line) and pension benefits (dashed line), conditional on experience, education, and district effects, in the years around the expiration of each district's pre-existing CBA. Each series shows the OLS point estimates and the 90 percent confidence intervals of the parameters δ_n in the equation $\ln y_{idt} = \sum_{n=-5}^{5} \delta_n \mathbb{1}(t = E_j = n) + \beta X_{it} + \theta_j + \varepsilon_{ijt}$, where y_{idt} is the gross salary or the pension benefit of teacher i working in district j in year t, E_j is the year of the expiration of district j's pre-existing CBA, X_{it} is a vector of years of experience fixed effects interacted with indicators for the highest education degree (Bachelor, Master's, PhD), and θ_j are district fixed effects. The coefficient δ_0 is normalized to zero. Standard errors are clustered at the district level.

Figure IV: Teachers' gross salaries and pension benefits: Event study by type of district

Panel A: Gross salaries

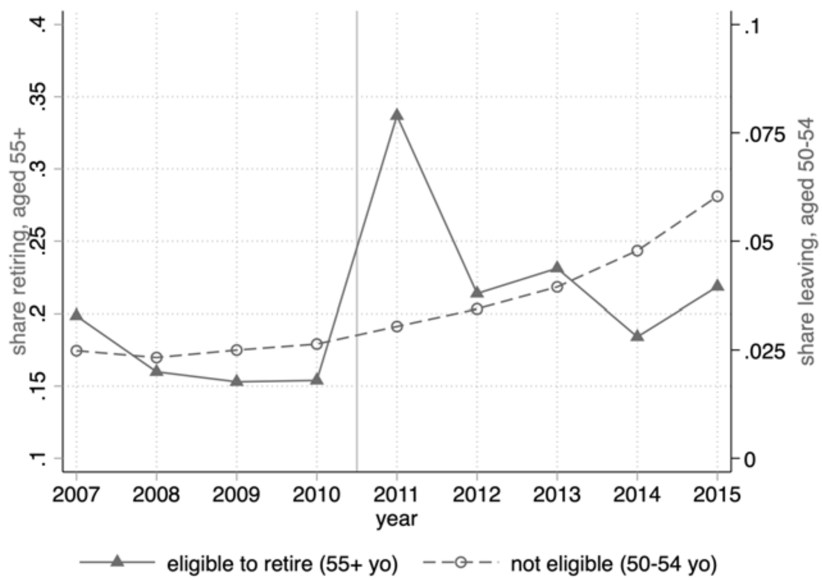


Panel B: Pension benefits



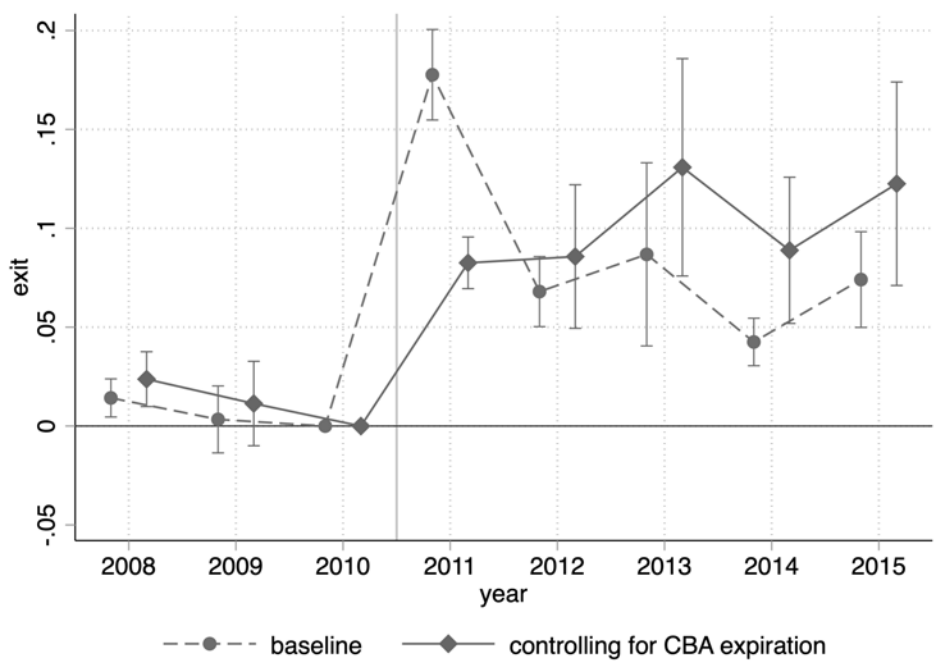
Note: The figure shows an event study of gross salaries (Panel A) and pension benefits (Panel B), conditional on experience, education, and district effects, in the years around the expiration of each district's pre-existing CBA and separately for flexible-pay (solid line) and seniority-pay districts (dashed line). Each series shows the OLS point estimates and the 90 percent confidence intervals of the parameters δ_n in the equation $\ln y_{idt} = \sum_{n=-5}^{5} \delta_n \mathbb{1}(t = E_j = n) + \beta X_{it} + \theta_j + \varepsilon_{ijt}$, where y_{idt} is the gross salary or the pension benefit of teacher i working in district j in year t, E_j is the year of the expiration of district j's pre-existing CBA, X_{it} is a vector of years of experience fixed effects interacted with indicators for the highest education degree (Bachelor, Master's, PhD), and θ_j are district fixed effects. The coefficient δ_0 is normalized to zero. Standard errors

Figure V: Exit Rates, By Retirement Eligibility



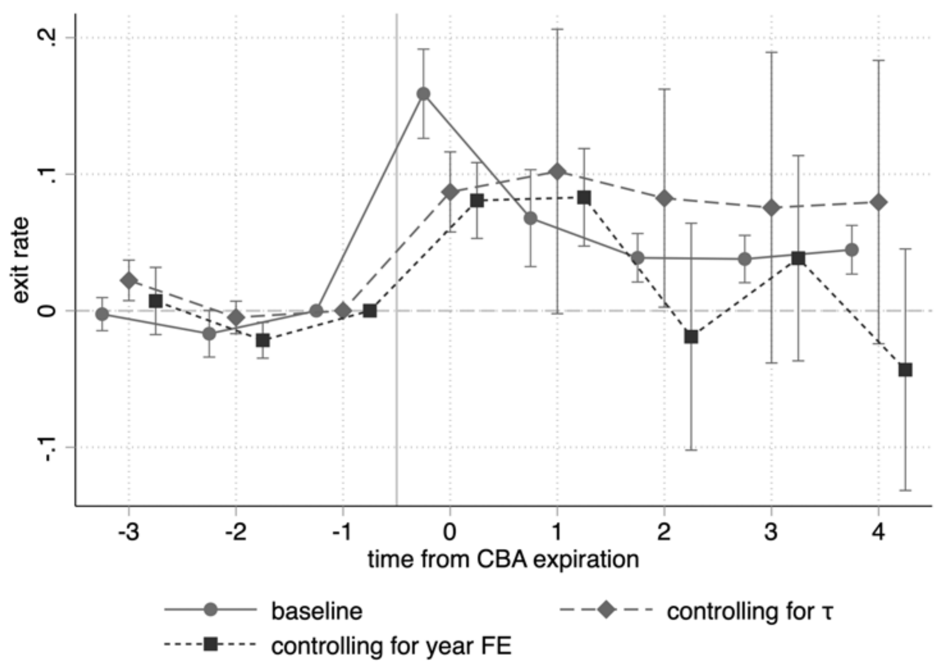
Note: Share of teachers exiting Wisconsin public schools, by retirement eligibility. Sample restricted to teachers aged 50-70 with at least 5 years of experience.

Figure VI: Event Study: Teacher Retirement Around Act 10



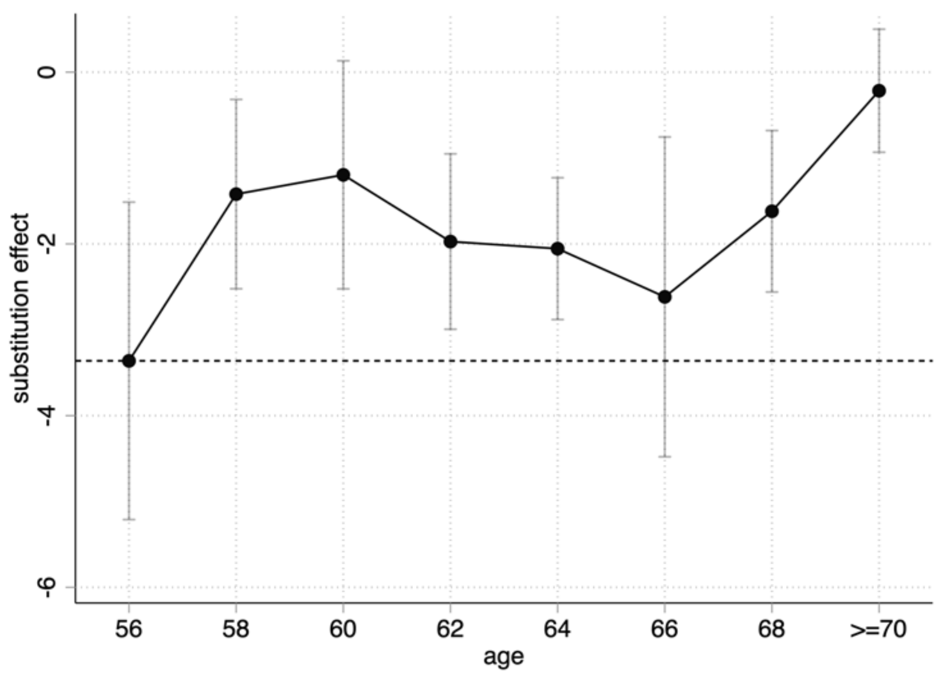
Note: The figure shows an event study of retirement rates conditional on experience, age, gender, and district fixed effects, in the years around the passage of Act 10 in 2011. Each series shows the OLS point estimates and the 90 percent confidence intervals of the parameters δ_n in the equation $e_{ijt} = \sum_{n=2007}^{2015} \delta_n \tau_n + \gamma X_{it} + \theta_j + \sum_{n=2007}^{2015} \eta_n \mathbb{1}(n > Exp_j)\tau_n + \varepsilon_{ijt}$, where e_{ijt} equals one if teacher i retires at the end of year t from district j, τ_t is an indicator for year t, the vector X_{it} includes an indicator for gender and quadratic polynomials in age and experience, θ_j are district fixed effects, and Exp_j is the year of expiration of district j's CBA. The coefficient δ_{2011} is normalized to zero. In the dashed series, the coefficients η_n are constrained to be zero. Standard errors are clustered at the district level.

Figure VII: Event Study: Teacher Retirement Around The Expiration of Districts' CBAs



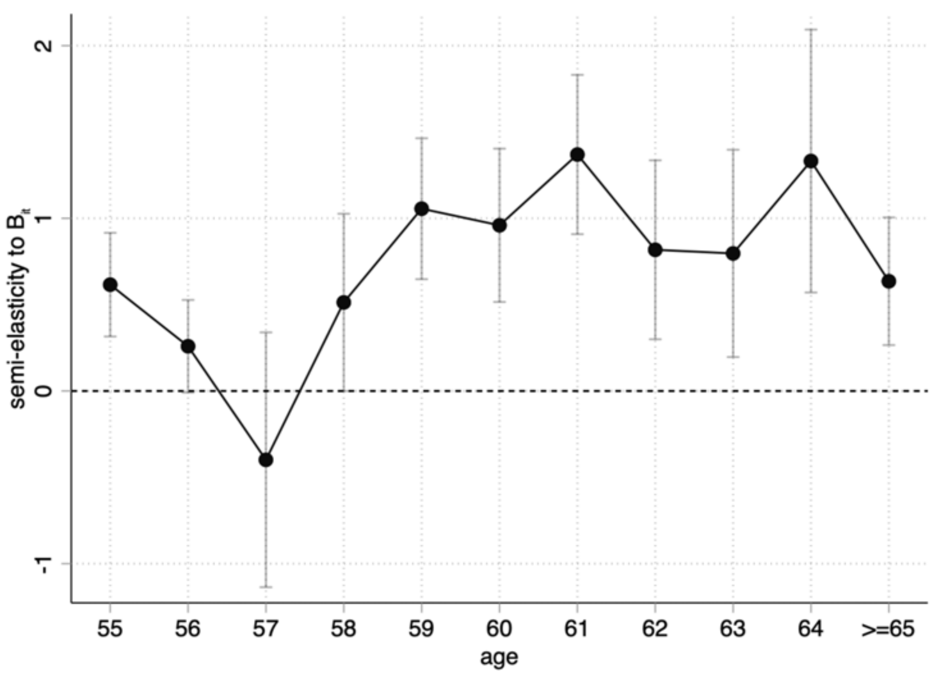
Note: The figure shows an event study of retirement rates conditional on experience, age, gender, and district fixed effects, in the years around the expiration of each district's CBA. Each series shows the OLS point estimates and the 90 percent confidence intervals of the parameters δ_n in the equation $e_{ijt} = \sum_{n=-5}^{5} \delta_n \mathbb{1}(t - Exp_j = n) + \gamma X_{it} + \theta_j + \tau_t + \varepsilon_{ijt}$, where e_{ijt} equals one if teacher i retires at the end of year t from district j, τ_t is an indicator for year t, the vector X_{it} includes an indicator for gender and quadratic polynomials in age and experience, θ_j are district fixed effects, and Exp_j is the year of expiration of district j's CBA. The coefficient δ_{2011} is normalized to zero. In the solid series, estimates of δ_n are obtained not controlling for τ_t. Standard errors are clustered at the district level.

Figure VIII: Semi-Elasticity of Retirement With Respect to Net Salaries, By Age



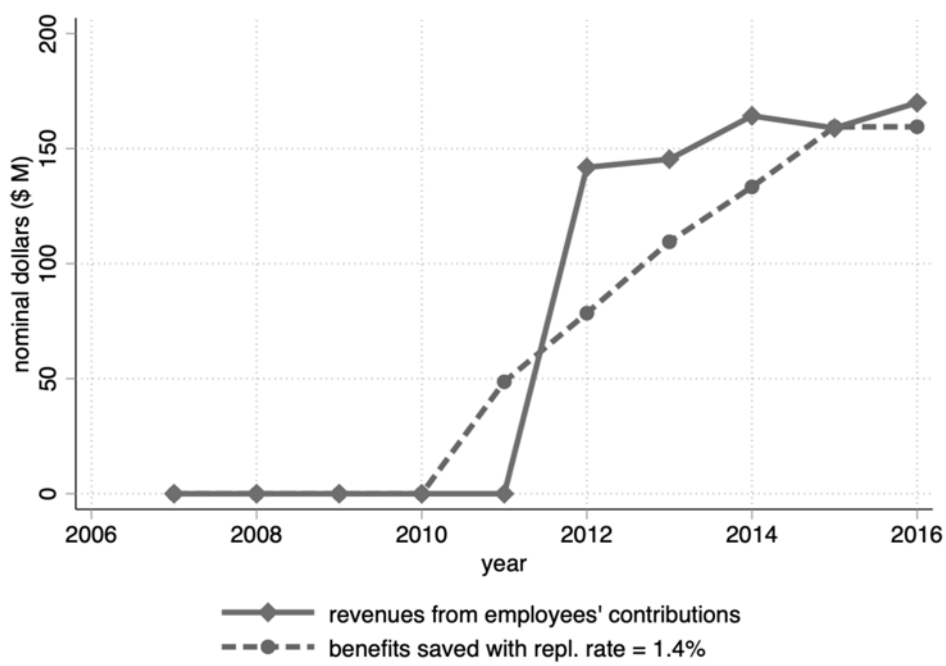
Note: 2SLS estimates and 90 percent confidence intervals of the parameters β_a in the equation $L_{it} = \sum_{a=55}^{70} \mathbb{1}(a_{it} = a)\beta_a \ln W_{it}(1 - \tau_t) + \gamma \ln B_{it} + \delta X_{it} + \omega_{it}$, where the variables W_{it} and τ_{it} represent the salary and contribution rate for teacher i in year t, the variable B_{it} represents the pension benefit for a teacher i who retires in year t, and a_{it} is a teacher's age. The vector X_{it} includes controls for the year 2011 and for age, experience, gender, and district fixed effects. Standard errors in parentheses are clustered at the district level.

Figure IX: Semi-Elasticity of Retirement With Respect to Pensions, By Age



Note: 2SLS estimates and 90 percent confidence intervals of the parameters β_a in the equation $L_{it} = \beta \ln W_{it}(1-\tau_t) + \sum_{a=55}^{70} \mathbb{1}(a_{it} = a)\gamma_a \ln B_{it} + \delta X_{it} + \omega_{it}$, where the variables W_{it} and τ_{it} represent the salary and contribution rate for teacher i in year t, the variable B_{it} represents the pension benefit for a teacher i who retires in year t, and a_{it} is a teacher's age. The vector X_{it} includes controls for the year 2011 and for age, experience, gender, and district fixed effects. Standard errors in parentheses are clustered at the district level.

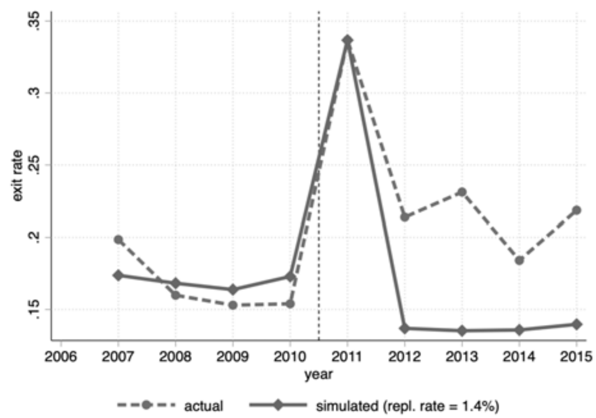
Figure X: Budget Savings Under Act 10 and Under Counterfactual Policy



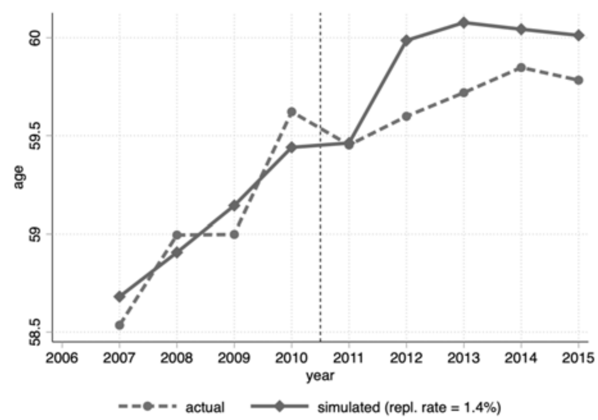
Note: The dashed line shows revenues from employees' contributions to the pension fund, for all Wisconsin teachers. The solid line shows savings achieved with the alternative budget-cutting policy presented in the text, and calculated as $S_{it} = (B_{it} - B'_t) * e'_{it} + B_{it} * (e_t - e'_{it})$ where B_{it} are pension benefits, B'_{it} are benefits calculated with a replacement rate of 1.4%, e_t is the retirement rate, and e'_t is the counterfactual retirement rate associated with a replacement rate of 1.4%.

Figure XI: Retirement Rates and Characteristics of Teachers Who Retire: Act 10 vs. Counterfactual Policy

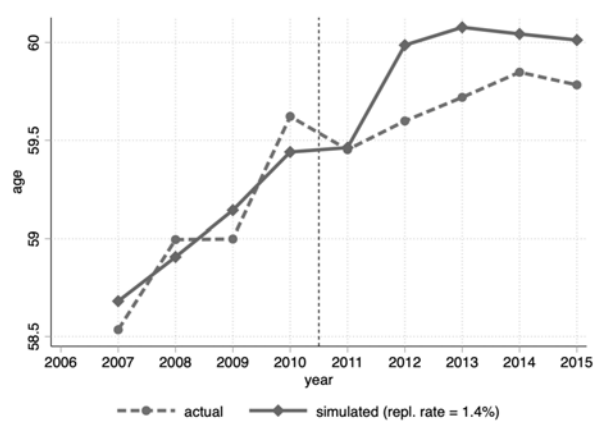
Panel A): Retirement Rates



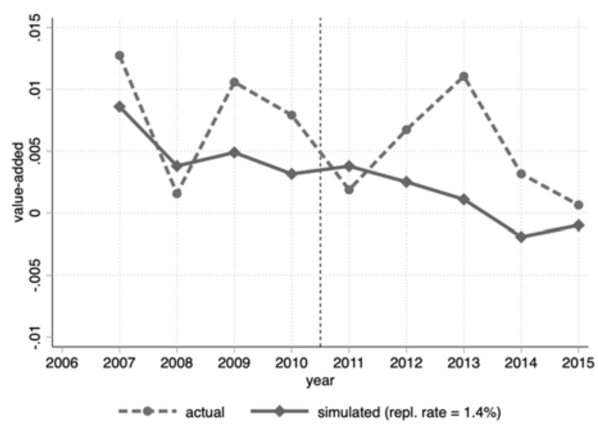
Panel C): Experience of Teachers Who Retire



Panel B): Age of Teachers Who Retire



Panel D): Value-Added of Teachers Who Retire



Note: The dashed lines show averages of retirement rates (panel A), age and experience of teachers who retire (panel B) and their value-added (panel B). The solid lines show averages of the same variables under a counterfactual policy which keeps employees's contributions at zero and lowers the retirement rate of pensions to 1.4% starting from 2011.

Appendix

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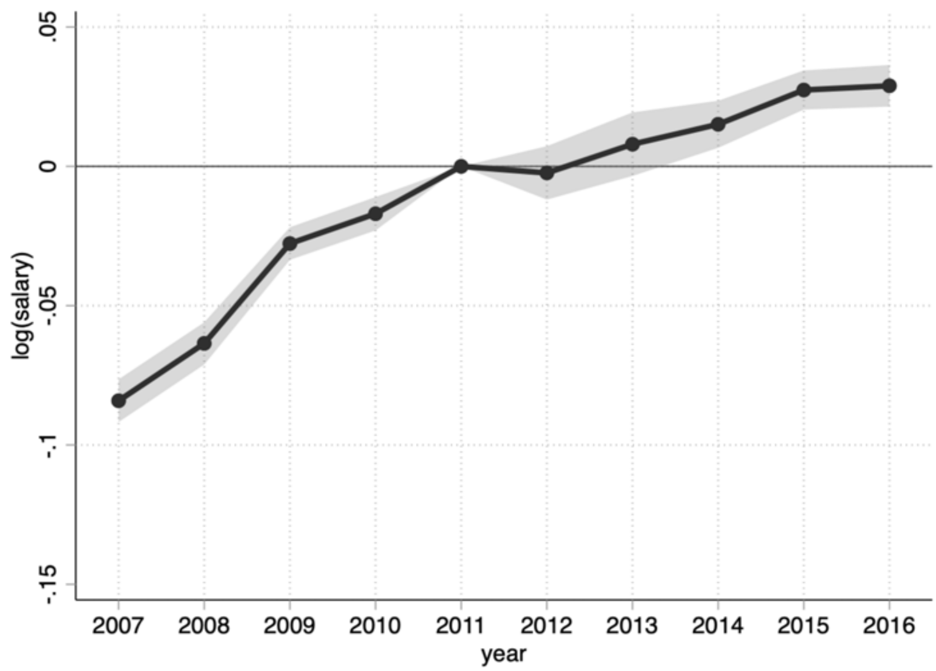
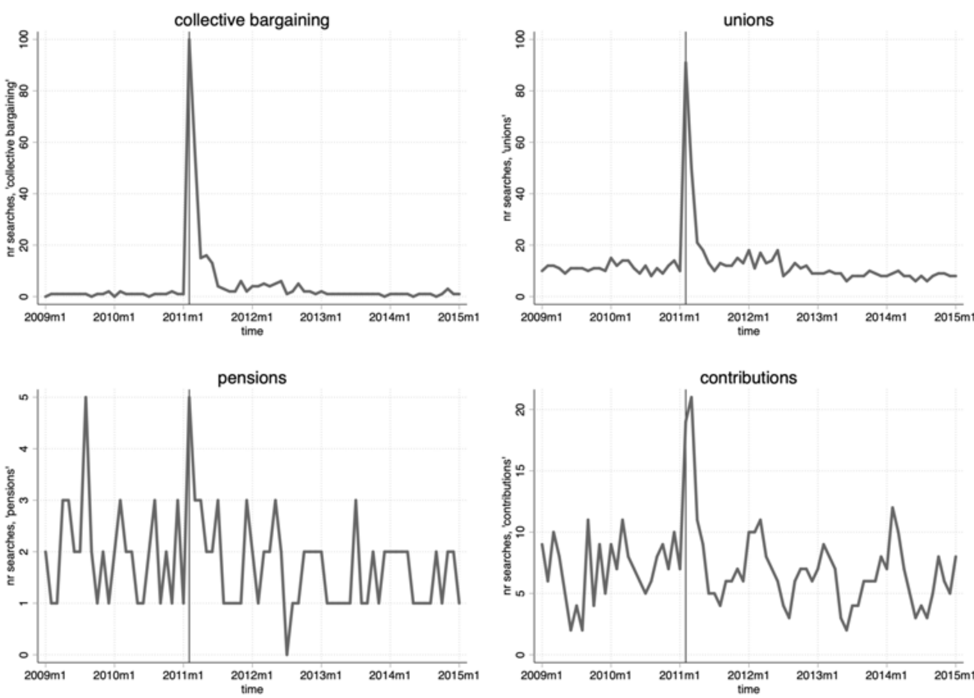
Appendix A Additional Tables and Figures

Figure AI: Trend in Teacher Salaries Between 2007 and 2016



Note: The figure shows OLS estimates and 90 percent confidence intervals of year coefficients δ_n in the equation $\ln w_{idt} = \sum_{n=2007}^{2016} \delta_n \mathbb{1}(t = n) + \beta X_{it} + \theta_j + \varepsilon_{ijt}$, where w_{idt} is the salary of teacher i working in district j in year t, X_{it} contains a quadratic polynomial in experience and education fixed effects, and θ_j are district fixed effects. The coefficient δ_{2011} is normalized to zero. Standard errors are clustered at the district level.

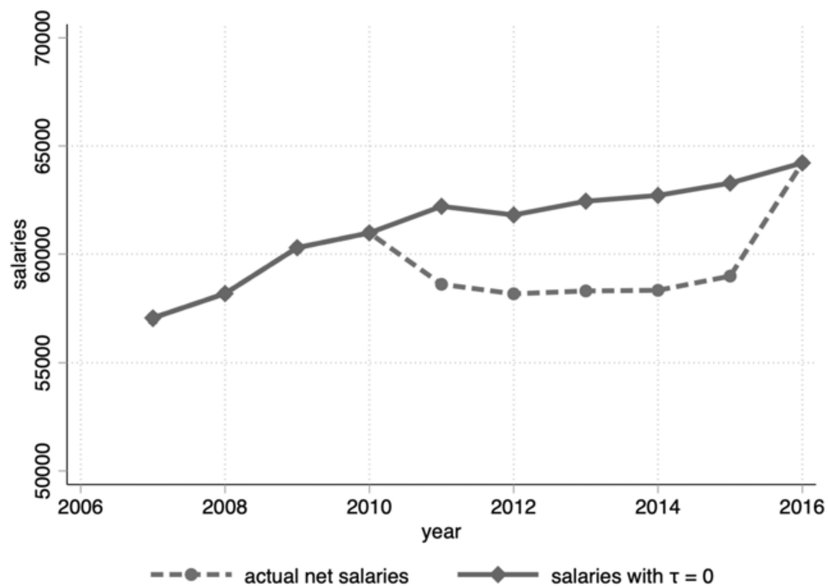
Figure AII: Salience of Act 10 Changes: Google Searches in Wisconsin



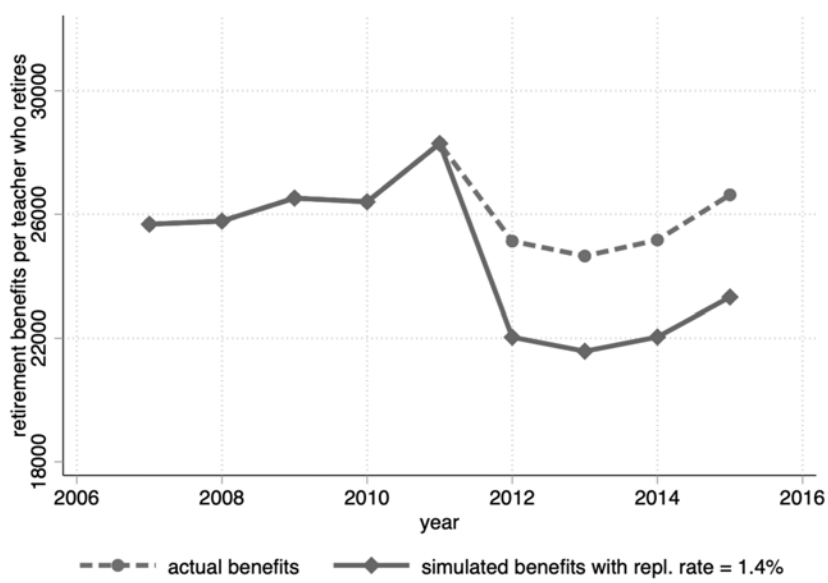
Note: Trends in Google Searches of the terms "collective bargaining," "unions," "pensions," and "contributions" performed from the US state of Wisconsin between 1/1/2009 and 1/1/2015.

Figure AIII: Net salaries and Pension Benefits Under Act 10 and Under Counterfactual Policy

Panel A): Net Salaries

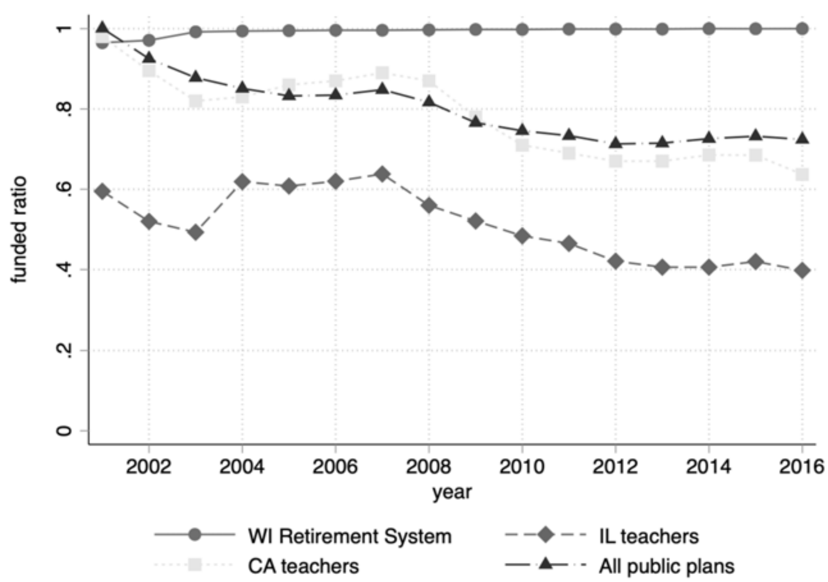


Panel A): Pension Benefits



Note: Net salaries (top panel) and pension benefits (bottom panel) in the data (dashed line) and under a counterfactual policy (solid panel). The counterfactual policy consists in reducing pensions' replacement rate from 1.6% to 1.4%, leaving employees' contributions to the pension fund at zero.

Figure AIV: Funding Ratio, WRS and Other Public Pension Plans



Note: Funding ratios between 2001 and 2016 for the Wisconsin Retirement System, the Illinois and California teacher pension plans, and all other public pension plans in the US. Data from the Public Pensions Database of the Center for Retirement Research at Boston College (CRR) and the Center for State and Local Government Excellence (SLGE).

Table AI: Retirement Semi-Elasticities to Salaries and Pensions. Two-Stages Probit, Dependent Variable Equals 1 If A Teacher Retires At The End Of The Year

	IV-Probit
	(1)
	Exiter, does not reappear
$\ln(W_t(1-\tau_t))$	-2.422***
	(0.455)
$\ln B_t$	2.112***
	(0.172)
$t = 2011$	0.543***
	(0.028)
N	68100

Note: The dependent variable equals one if a retirement-eligible teacher exits at the end of the academic year. The estimation is done using a two-stages probit, using the first stage in equation (21). The variables W_{it} and τ_t represent the salary and contribution rate for teacher i in year t. The variable B_{it} represents the pension benefit for a teacher i who retires in year t. All specifications include controls for the year 2011, for quadratic polynomials in age and experience, for gender, and for district fixed effects. Standard errors in parentheses are clustered at the district level. ** ≤ 0.1, ** ≤ 0.05, *** ≤ 0.01.