Retirement Responses to Changes in Salaries and Pensions: Evidence from Public School Teachers *

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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 studies this question by examining the retirement responses to a reform that simultaneously changed salaries and pensions of public school teachers. In 2011, Wisconsin's Act 10 ended collective bargaining over teachers' pay schedules and increased employees' contributions to the pension fund. The first provision triggering a decline in gross salaries and – subsequently – in future defined-benefits (DB) pensions for older teachers, and the second led to a decline in net salaries of all teachers. I use the staggered timing of implementation of the two provisions, together with a simple lifecycle model of consumption and leisure, to estimate the retirement elasticities to salaries and pensions and to calculate bounds of the income and substitution effects. Estimates indicate large substitution effects of a decline in net pay, and a more muted income effect of a decline in pensions. Furthermore, my findings indicate that teachers value one dollar of salaries more than one dollar of pensions. I use the estimated elasticities as summary statistics to evaluate the effect of an alternative budget-cutting policy that reduces pensions instead of net salaries. This alternative policy would lead to fewer, older, and lower-quality teachers retiring compared with Act 10.

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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. In 2011, twenty percent of private sector workers and nearly 80 percent of all state and local public employees were entitled to a defined-benefits (DB) pension upon retirement, whose benefits are calculated as a function of the most recent salaries.[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 contribute very little towards these benefits, pension liabilities of currently active workers are underfunded in the majority of states, for a total of almost $500 billion.

In spite of the large burden this form of compensation places on states' budgets, little is known on how DB pensions affect workers' labor supply and retirement behavior. While plans for different types of workers vary in their generosity, they share the common feature of deferring a substantial portion of a worker's lifetime compensation to the future. On one hand, this type of compensation structure could attract better workers, incentivize effort, and minimize turnover, while at the same time protecting workers from longevity risk (Gustman et al., 1994). On the other hand, the existence of these plans could create costs for some workers and be justified by political, rather than economic, reasons. DB pensions are most prevalent in highly unionized sectors, where unions typically act in the interest of older workers (Gustman et al., 1994), and generous pensions are often accompanied by lower salaries earlier on in a worker's career, which penalizes younger workers (Ehrenberg, 1980).

Estimating workers' preferences for salaries and pension benefits and the subsequent retirement responses to changes in these variables requires separate exogenous shifts in both of these forms of compensation, which are rare. 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 paid and the way they contribute to the pension fund, with a timing that varied across school districts.

[1] Bureau of Labor Statistics, *Monthly Labor Review*, December 2013.

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

First, the reform triggered a contemporaneous decline in gross salaries and pension benefits of older teachers through changes in the rules governing collective bargaining. In particular, Act 10 prohibited unions from negotiating seniority-based salaries with school districts and gave districts the freedom to decide on teachers' pay. I demonstrate that this change led to a 7.5 percent decline in salaries for teachers who were close to retirement (in line with the increase in pay for younger teachers after the same reform documented by Biasi, 2018). 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 pension benefits.

Second, Act 10 shifted the burden of the financing of pension benefits from the state's budget onto employees, by raising employees' pension contribution from zero to 5.8 percent in 2012, 6.65 percent in 2013, and 7 percent in 2014. This increase in the contribution rate acted as an increase payroll taxes; since gross salaries did not adjust upwards, this translated into a 8.3 percent decline in net salaries of all active teachers immediately following Act 10. This policy change, however, had no effects on pension benefits, which are instead calculated as a function of gross (not net) salaries, since the total (employer plus employee) contribution to the pension fund remained the same.

Importantly, the timing of the changes in gross salaries and pensions and in net salaries 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, school districts' pre-existing collective-bargaining agreements (CBA) were binding until their expiration; until that point, districts could not exercise their freedom over pay setting. As a result, gross salaries and pensions only started to decline after the CBA expiration. Since these expiration dates depend on the electoral cycle, they can be plausibly considered exogenous and can be used to identify the effects of changes in salaries (stemming from changes in the contribution rate) and in pensions (stemming from changes in gross salaries conditional on net salaries) on teachers' retirement behavior.

A simple analysis of retirement rates indicates that teachers responded vigorously to the changes in salaries and pensions: After Act 10, retirement rose from 15 to 34 percent. The timing of this increase across districts suggests that 21 percent of it can be attributed to the decline in net salaries starting from 2011, whereas 31 percent can be ascribed to the fall in gross salaries and pension benefits after the expiration of districts' CBAs. Retirement rose more for low-quality teachers relative to high-quality ones after the expiration of CBAs, but not after the increase in the contribution rates. This is consistent with the end of CB disproportionately affecting salaries

of low-quality teachers (Biasi, 2018) and with the increase in the contribution rate affecting all employees in the same way. Lastly, retirement rose more after the expiration of CBAs in districts which discontinued the use of a salary schedule after Act 10 (flexible-pay districts Biasi, 2018) compared with all others.

What do these retirement patterns tell us about how teachers value different forms of compensation? The relationship between salaries, pensions, and the retirement decision can be best seen through the lenses of a simple 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 (which the worker receives for as long as she is employed) and pension benefits (which she starts receiving once she retires). The solution of this maximization problem yields a retirement demand function, which depends on salaries and pension benefits. Changes in these variables give rise to income and substitution effects of changes in these variables. Following an increase in salaries, the income effect makes the worker want to consume more of all goods, including leisure, because her lifetime income will be higher; this raises the retirement probability. The substitution effect instead lowers the retirement probability because leisure is now more expensive. The overall effect on retirement is therefore ambiguous. Following an increase in pension benefits, on the other hand, both the income effect and the substitution effect increase the retirement probability, the first due to an increase in lifetime income and the second due to a decline in the price of leisure.

Using the exogenous changes in salaries and pensions introduced by Act 10, I derive bounds to the income and substitution effects by estimating the retirement elasticities to changes in salaries and pension benefits. The elasticity of retirement with respect to changes in net salaries, if negative, provides a lower bound on the intertemporal substitution (or Frisch) elasticity. The elasticity of retirement with respect to changes in pension benefits, on the other hand, represents an upper bound on the income effect. Using the policy changes (namely the increase in the contribution rate and the timing of CBA expiration) as instruments, I estimate a lower bound for the substitution elasticity equal to 0.87 and an upper bound on the income effect equal to 0.27. These estimates suggest 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, however, also indicate that teachers are more responsive to changes in net salaries than they are to equally-sized changes in retirement benefits. This sug-

gests 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 retirement benefits as sufficient statistics to evaluate the 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 study the effects of this policy on retirement rates and on the composition of the pool of retiring teachers with respect to a range of observable characteristics. The results of this counterfactual exercise show that a cut in pensions (instead of a cut in salaries) 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, 2000; 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).[3] 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 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 constitute bounds for 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

[3] 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.

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.[4] 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.[5] 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

[4] 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).

[5] 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).

"formula multiplier" r, equal to 1.6 percent.[6] Benefits are capped to 75 percent of final average earnings. The formula is as follows:

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

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.[7] 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.[8] 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

[6] 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.

[7] 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).

[8] 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.

stipulated CBAs to one year; and lastly, it prohibits the automatic collection of union dues from employees' paychecks.[9]

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 unilaterally 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

[9] 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.

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 II 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 I shows that the expiration and extension dates are largely unrelated to districts' observable characteristics.[10] 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 universe of Wisconsin teachers. I combine it with information on post-Act 10 salary structures for each district, drawn from employee handbooks, and on districts' pre-existing CBAs. Lastly, I link teacher records with student test scores 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).

I draw information on the ***population of Wisconsin teachers*** from the *PI-1202 Fall Staff Report - All Staff Files* for the years 2007–2015, made available by the Wisconsin Department of Public Instruction (WDPI). These files contain information on all individuals employed by the WDPI

[10]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.

in each year and include personal and demographic information, education, years of teaching experience, and characteristics of job assignments (including total salary, fringe benefits, grades and subject taught, full-time equivalency (FTE) units, and school and district identifiers). Salaries are expressed in 2015 dollars and in FTE units. For most of my analyses I restrict attention to teachers who are eligible to receive retirement benefits, i.e. those with at least 5 years of experience and who are at least 55 years old.[11]

I collected information on districts' ***pre-Act 10 CBAs*** from a variety of sources. The first are districts' union contracts, stipulated before 2011 and set to expire either in 2011 or 2012 and accessed using a series of Google searches. The second 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. School boards' meeting minutes from 2011 are the third source; most of these documents describe whether CBAs were set to expire in 2011, whether an extension was granted, and for how long.

Using these three sources, I was able to compile expiration and extension dates for 211 out of 426 school districts, employing 79 percent of all teachers. These data are summarized in Table II.

Student-level data include 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 to 8, as well as demographic characteristics such as gender, race and ethnicity, socioeconomic (SES) status, migration status, English-learner status, and disability. The WKCE was administered in November of each school year, whereas the Badger test was administered in the spring. To account for this change, 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.

I collected information on districts' pay schemes from their 2015 ***employee handbooks***, available for 224 out of 422 districts (including seven high school districts and 164 districts with information on CBA expiration dates), which enroll approximately 83 percent of all students.[12]

[11] I exclude long- and short-term substitute teachers, teaching assistants and other support staff, and contracted employees since salaries for these workers are calculated differently from those of permanent teachers. Due to evident mistakes in the reporting of salary information, I discard information for teachers in the school district of Kenosha, as well as for those in the school district of Milwaukee for the year 2015.

[12] Handbooks are published on each district's website. Unclassified districts (i.e., those for which handbooks are not available) either do not have a website or do not make their handbook public. Biasi (2018) compares FP and SP

As in Biasi (2018), I classify a district as SP for the entire post-Act 10 period if its 2015 handbook contains a salary schedule and does not mention rewards for performance or merit and as FP otherwise. If a schedule is published but bonuses linked to performance are mentioned, the district is classified as FP.[13]

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). Albeit not a perfect measure of talent (Rothstein, 2010; Kraft, 2017; Jackson, 2018), VA is generally considered a good signal of a teacher's effectiveness (Kane and Staiger, 2008; 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 leverage the identification approach of Rivkin et al. (2005), who face the same issue using data from Texas. I then combine this approach with the estimation method of Chetty et al. (2014). This approach, outlined in Appendix B of Biasi (2018), relies on teacher turnover across grades and/or across schools, as in Rivkin et al. (2005). In the absence of turnover, all teachers in the same grade and school would be assigned the same student test scores every year; the separate identification of their individual effects would not be possible. With multiple years of data and in the presence of turnover, however, teacher switches across schools or grades allow me 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.[14]

districts with unclassified districts. The latter are smaller, enroll more disadvantaged students, pay lower salaries, and are disproportionately located in rural areas.

[13] It is possible that districts classified as FP did not change pay scheme immediately after the passage of Act 10, but after a few years. By the same token, it is possible that districts classified as SP as of 2015 switched to FP after 2015. For this reason I end my analysis in 2015.

[14] Importantly, teacher turnover makes it possible to more precisely identify not only the effects of the teacher who switches, but also the effects of all other teachers in her same grade and school at any point in time.. The aggregation of test scores at the grade level also overcomes one of the most problematic form of selection, which occurs within schools and grades and across classrooms (Rivkin et al., 2005). The (forced) use of grade-school estimates circumvents this form of selection and is in practice equivalent to an instrumental variable estimator based on grade rather than

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. 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 studying how salaries and pension benefits of retirement-eligible teachers changed 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, leaving the total contribution (employee plus employer) unchanged. Second, the Act deprived unions of the power to negotiate teachers' salary schedules with each school district, in practice giving districts the freedom to set 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, employees's rates were zero and the entire pension contribution (11.6 percent of a teacher's annual salary) was made by the employer (i.e., the school district). After Act 10, the burden was shifted from the employer to the employees. As a result, 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, the increase in the contribution rate acts as a cut in net pay for all active teachers, similar to 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 on net pay could be much smaller or even zero (see Gruber, 1997; Fullerton and Metcalf, 2002, for example).

classroom assignment.

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

To study how net salaries changed after Act 10, I perform an event study of conditional net salaries of retirement-eligible teachers in the years surrounding the reform. I estimate:

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

where w_{it}^{net} is the salary of teacher i working in district j in year t, net of the pension contribution rate; X_{it} is a vector of controls, including fixed effects for the highest education degree and a quadratic polynomial in experience; and θ_j are district fixed effects. To account for the fact that nominal salaries were trending upwards over time in the years leading to Act 10 (see Figure **??**), I remove a linear pre-trend from the variables w_{ijt}^{net} and X_{it}, estimated using salary data from the years 2006 to 2010. Normalizing the coefficient δ_{2011} to equal 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. Removing the pre-trend, conditional net salaries appear 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. This indicates that teachers' salaries are not perfectly competitive and did not adjust upwards to compensate for the increase in the contribution rate; on the opposite, net salaries declined even more than just the increase in the rate of contribution.

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, retained teacher compensation bargaining only for base pay, and limited that bargaining to the rate of inflation.[16] This implies that districts were given the flexibility to unilaterally decide on teacher pay. Importantly, however, the CBAs districts had stipulated before Act 10 remained binding until their expiration; as a result, districts could exercise their newly acquired flexibility only after the expiration of their pre-existing CBA.

Biasi (2018) shows that this newly acquired flexibility triggered a sizable increase in pay for higher-quality, low-seniority teachers, especially in certain districts. Given that districts' budgets remained largely unchanged (in fact they were slightly reduced after the budget restrictions introduced by Act 23; Biasi, 2018), this relative increase in pay for some younger teachers could have led to a reduction in salaries for more experienced teachers (who are ex ante more expen-

[16]The rate of inflation is defined as the percentage change in the consumer price index.

sive).

To test this assumption, I perform an event study of conditional salaries of retirement-eligible teachers in a ten-years window surrounding the expiration of each district's CBA. I estimate:

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

where w_{it} is the net salary of teacher i working in district j in year t and , Exp_j is the year of expiration of district j's CBA. As before, I remove a linear pre-trend from w_{ijt} and X_{it}, and 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 the expiration. Estimates of δ_n are indistinguishable from zero for $n < 0$, indicating that conditional salaries were flat in the years leading to a CBA expiration. After the expiration, however, salaries started to slowly decline; after five years, they had fallen by 7.5 percent lower relative to the year of expiration of the CBA. This confirms that, conditional on experience and education, gross salaries of older and more experienced teachers declined after the expiration of each district's CBA.

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 pension benefits of teachers who were to retire after 2011. The dashed line in Figure III shows the trend in pension benefits of all retirement-eligible teachers in a given year, calculated using the benefits formula and observed gross salaries and conditional on age and experience.[17] Due to the fall in gross salaries, pension benefits fell by 1.1 percent one year after the expiration 2012, 2.2 percent two years after, and 5.8 percent five years after a CBA expiration.

Differences Across Districts Biasi (2018) shows that school districts used their newly acquired flexibility in terms of teacher pay setting in different ways: Some continued setting pay using a seniority-based salary schedule (salary-schedule districts), whereas others discontinued the use of a schedule altogether and started rewarding other individual attributes (flexible-pay districts). Figure IV (top panel) shows event study estimates of conditional gross salaries for

[17] The point estimates and confidence intervals shown in Figure III (dashed line) are obtained re-estimating Equation (2) using the natural logarithm of pension benefits as a dependent variable, and including a quadratic polynomial in age as a control.

retirement-eligible teachers, separately for flexible-pay and for seniority-pay districts. Salaries declined significantly more for teachers in flexible-pay districts (solid line), by 3.7 percent, 5.0 percent, and 9.0 percent one, two, and five years after a CBA expiration. The decline was more contained in seniority-pay districts (dashed line), and equal to 1.8 percent, 3.7 percent, and 6.9 percent one, two, and five years after the expiration of a CBA. As expected, also pension benefits of retirement-eligible teachers declined more in flexible-pay districts compared with seniority-pay districts (Figure IV, bottom panel). These estimates suggest that flexible-pay districts used their flexibility to reward low-seniority teachers more, at the expense of more experienced retirement-eligible teachers.

Differences by Teachers' Value-Added. Biasi (2018) also shows that flexible-pay districts started paying higher salaries to teachers with higher value-added. By the same token, it is possible that the decline in salaries was larger for lower-quality, retirement-eligible teachers after the expiration of districts' CBAs. As a test of this hypothesis, Figure AI (top panel) shows event study estimates of conditional gross salaries for teachers with value-added in the top 25 and bottom 75 percent of the state distribution. These estimates do not show evidence of significant differences in the evolution of salaries among teachers with different value-added. As a result, also pension benefits did not differ (Figure AI, bottom panel).

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 to better characterize the timing of these changes , I estimate the following equation:

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

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 all the variables are deprived of a linear pre-trend. In this specification the parameter $\alpha^{post2011}$ 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 α^{Exp} captures instead the change in the dependent variable following the expiration of the CBA in Exp_j relative to the years preceding 2011.

Column 1 of Table III shows estimates of the parameters $\alpha^{post2011}$ and α^{Exp} on gross salaries. 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 (with an estimate for *after Act 10* equal to -0.021, Table III, column 1, significant at 5 percent). This was likely due to the introduction of a limit on the annual growth rate of base salaries equal to the rate of inflation, imposed by Act 10 to all districts in 2011. 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 gross salaries declined more sharply after the expiration of districts' CBAs than in 2011, the bulk of the decline in net salaries happened immediately after Act 10 was passed in 2011. Estimates of $\alpha^{post2011}$ and α^{Exp} in column 3 of Table III indicate that net salaries fell by 8.1 percent immediately after Act 10 (with an estimate for *after Act 10* equal to -0.081, Table III, column 3, significant at 1 percent). This estimate is not surprising 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 (with an estimate for *after CBA expiration* equal to -0.041, Table III, column 3, significant at 1 percent). This was likely due to the decline in gross salaries estimated in column 1 and to a slight increase in the rate of contribution to the pension fund (to 5.9 percent in 2013, 6.65 percent in 2014, and 7.0 percent in 2015).

Estimates of α^{post} and α^{Exp} on pension benefits are shown in column 5 of Table III; consistently with a decline in gross salaries concentrated in the aftermath of the expiration of districts' CBA, the bulk of the decline in benefits, equal to 1.6 percent on average, happened after 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).

As districts' CBAs pre-dating Act 10 expired either in 2011, 2012, or 2013, districts had to decide on how to set teachers' pay. Some districts decided to postpone this decision and to extend the validity of the CBAs by one or two years. To investigate whether salaries changed between the expiration of the original CBA and the expiration of the extension, in columns 2, 3, and 6 of Table III I re-estimate equation (3) including an indicator 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):

$$\ln y_{ijt} = \alpha^{post}\mathbb{1}(t > 2011) + \alpha^{Exp}\mathbb{1}(t > Exp_j) + \alpha^{Ext}\mathbb{1}(t > Ext_j) + \gamma X_{it} + \theta_j + \varepsilon_{it} \qquad (4)$$

In this equation, the parameter α^{Exp} captures the average change in the dependent variable after the expiration of a CBA agreement but before the expiration of its extension, for school districts

with an extension; the parameter α^{Ext} captures instead the change following the expiration of the extension. Estimates of α^{Ext} on gross salaries, net salaries, and pension benefits, shown in columns, 2, 4, and 6 of Table III respectively, indicate that the bulk of the change in salaries and pensions happened after the expiration of CBA extensions. Specifically, while all these forms of compensation remained unchanged between an expiration and an 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 retirement-eligible teachers respond to these changes in net salaries and future pension benefits? In this section I focus on labor supply responses by studying teachers' retirement rates across districts following Act 10. The goal of this exercise is to exploit differences in the timing of changes in salaries and pensions to back out workers' preferences for these two forms of compensation.

Retirement After 2011. Act 10 was followed by a spike in exit rates of teachers who were eligible to receive retirement benefits. While 15 percent of retirement-eligible teachers left at the end of 2010, 33.7 percent left at the end of 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 to 3.1 in 2011, 3.4 in 2012, and 6.0 in 2015 (Figure V, dashed line). In the rest of the paper, I assume that retirement-eligible teachers who leave enter retirement and remain in this state.

5.1 Decomposing Retirement Responses to Changes in Salaries and Pensions

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 changes in net and gross pay driven by the staggered expiration of districts'

pre-Act 10 CBAs. The intuition behind the identification strategy is the following. Since the decline in net pay caused by the increase in the pension contribution rate happened at the end of 2011 for all districts but the change in gross salaries (and therefore in 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 the decline in net salaries, while any retirement following a CBA expiration can be attributed to a combination of a decline in salaries and a decline in pension benefits.

Identification Assumptions. This identification strategy relies on two 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 unique drivers of the spike in retirement were the changes in salaries and pensions introduced by the reform. Act 10, however, was a large and controversial reform package, perceived by many teachers as an attack to the teaching profession (Davey and Greenhouse, 2011), and which led to protests and unrest in Madison and in the rest of the state.[18] If the disapproval for the whole reform package 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 overestimate teachers' retirement response to a change in net salaries.

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 population, even before the reform had been approved. A simple Google search of terms related to Act 10 such as "collective bargaining," "unions," "pensions," and "contributions," shown in Figure AII, reveals a spike in searches around the time Act 10 was passed in February 2011, which suggests that people were aware of the changes being introduced by the reform.

[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.

5.2 Retirement Responses to Changes in Net Salaries

To estimate teachers' retirement responses to the changes in net salaries, I perform an event study of retirement rates in a ten-years window around the passage of Act 10 in 2011. I estimate:

$$e_{ijt} = \sum_{n=2007}^{2015} \delta_n \tau_n + \gamma X_{it} + \theta_j + \sum_{n=2007}^{2015} \eta_n \mathbb{1}(n > Exp_j)\tau_n + \varepsilon_{ijt} \tag{5}$$

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 inclusion of the term $\sum_{n=2007}^{2015} \eta_n \mathbb{1}(n > Exp_j)\tau_n$ in this equation allows me to flexibly control 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 change in retirement rates between year n and 2010.

For the sake of comparison, I first estimate δ_n imposing $\eta_n = 0$ – i.e., not controlling for the expiration of a CBA. These estimates, shown in the dashed series in Figure VI, indicate that teacher retirement soared after the passage of Act 10, increasing 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.

Imposing $\eta_n = 0$, however, implies that the estimates of δ_n capture the retirement responses to all the provisions of Act 10, including the responses to the decline in pension benefits which only happened in each district after the expiration of the CBA. To isolate the retirement responses to the changes in net salaries triggered by the increase in the contribution rate, the solid series in Figure VI shows estimates of δ_n controlling for the expiration date of districts' CBAs, i.e., allowing η_t in equation (5) to be different from zero. These estimates show a smaller, but still large increase in retirement following the passage of Act 10, equal to 7.3 percentage points (or 43 percent) in 2011, 3.2 in 2012, and 7.5 in 2015. Absent any other behavioral responses to Act 10, these estimates imply that the fall in net pay that followed the increase in the contribution rate mandated by Act 10 triggered an increase in retirement for teachers eligible to collect benefits.

5.3 Retirement Responses to Changes in Gross Salaries and Pension Benefits

How did teachers respond to the decline in gross pay and pension benefits that followed the expiration of districts' CBAs? To estimate these responses I perform an event study of retirement

rates in a nine-years window around the expiration of each district's CBA. I estimate:

$$e_{ijt} = \sum_{n=-5}^{5} \delta_n \mathbb{1}(t - Exp_j = n) + \gamma X_{it} + \theta_j + \tau_t + \varepsilon_{ijt} \tag{6}$$

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, the inclusion of year fixed effects τ_t allows me to parse out any retirement responses to changes in net salaries driven by changes in the pension contribution, which affected all districts at the same time.

I start by estimating δ_n not controlling for year fixed effects. These estimates, shown in the solid series in Figure VII, indicate that teacher retirement increased after the expiration of a CBA, by a large 16.5 percentage points the year of the expiration, 6.4 percentage points one year after the expiration, and 3.9 percentage points four years after the expiration.

As before, however, these figures combine the retirement responses to all the provisions of Act 10, including the responses to the increase in the pension contribution rate, which started in 2011 – the same year of expiration of CBAs for 104 districts (49 percent). To parse out the responses to changes gross salaries and in retirement benefits from those to changes in net salaries, the long-dashed series in Figure VII shows estimates of δ_n controlling for an indicator for the year 2011 and for the pension contribution rate. Including these controls reduces the estimate for the increase in retirement following a CBA expiration, which remains however still large at 10.6 percentage points the year of the expiration, 9.9 percentage points one year after the expiration, and 8.2 percentage points four years after the expiration. As a robustness check, the long-dashed series in Figure VII shows estimates of δ_n controlling for year fixed effects: These estimates indicate that retirement increased by 8.4 percentage points the year of the expiration, 8.4 percentage points one year after the expiration, with no significant difference four years after the expiration.

Taken together, these estimates indicate that teachers' retirement responded not only to the decline in net pay, but also to the change in future pension benefits driven by changes in gross salaries following the expiration of districts' CBAs.

Exit in Flexible vs. Seniority Pay Districts If the estimates in Figure VII are responses to changes in gross salaries and pension benefits, they should be larger in flexible-pay districts, as pay of older teachers declined by more in these districts. To check this, Figure VIII shows

estimates of equation (6) separately for flexible-pay and seniority-pay districts. These estimates confirm the hypothesis. In flexible-pay districts, retirement rose by 7.7 percentage points the year of expiration of a CBA (or 45 percent relative to a pre-2011 average retirement rate of 0.17), 18.8 percentage points two years after (111 percent), and 20.3 percentage points (119 percent) four years relative to the year before the expiration. In seniority-pay districts, on the other hand, retirement rose by 6.5 percentage points the year of expiration of a CBA (or 38 percent), 7.8 percentage points the year after (46 percent), and it was not significantly different four years after relative to the year before the expiration.

Exit for High vs. Low Value-Added Teachers Figure AI did not show differences in salary declines among high and low value-added teachers after Act 10. It might be possible, however, that teachers with lower value-added expect their gross salaries and pension benefits to decline more after Act 10 relative to teachers with higher value-added, consistently with Biasi (2018), and retire at a higher rate as a result. I test this hypothesis in Figure IX, which shows estimates of equation (6) separately for teachers with value-added in the top 25 percent of the distribution (solid line) and in the bottom 75 percent. Retirement rates of teachers in the top quartile increase only by a maximum of 4.7 percentage points the year of expiration of districts' CBAs, and are indistinguishable from pre-expiration levels four years after the expiration. Retirement rates of teachers with value-added in the three bottom quartiles, on the other hand, increase by a maximum of 8.0 percentage points the year after a CBA expiration. These estimates provide additional suggestive evidence that the rise in teacher retirement following the expiration of districts' CBAs was due to the changes in gross salaries and pension benefits.

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:

$$e_{ijt} = \alpha^{2011}\mathbb{1}(t = 2011) + \alpha^{post}\mathbb{1}(t > 2011) + \alpha^{exp}\mathbb{1}(t \geq Exp_j) + \alpha^{ext}\mathbb{1}(t \geq Ext_j) + \gamma X_{it} + \theta_j + \varepsilon_{ijt} \tag{7}$$

Estimates of the parameters α^{2011}, α^{exp}, α^{ext}, and α^{post} in this specification allow to gauge 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 that happened in 2011, but before the expiration of CBAs or of their extension; α^{post} captures the change in retirement rates that

happened after 2011, but before the expiration of CBAs or of their extension; and 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. An estimate of 0.078 for *t = 2011* indicates that, in 2011 but before the expiration of CBAs, retirement rates increased 7.8 percentage points across Wisconsin districts, or 47 percent compared with an average pre-2011 rate of 0.17 (Table IV, column 1, significant at 1 percent). After 2011 but before CBA expiration, retirement rates declined by 5.9 percentage points (with an estimate of *t > 2011* equal to -0.0592, Table IV, column 1, 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 1, p-values equal to <0.001 and 0.16).

Columns 2 and 3 of Table IV show estimates of equation 7 separately for flexible-pay and seniority-pay districts. Retirement rates in 2011 increase more in flexible-pay districts (estimate of *t = 2011* equal to 18.3 percentage points, column 2, significant at 1 percent) compared with seniority-pay districts (7.1 percentage points, column 3, significant at 1 percent). After the expiration of a CBA or its extension, however, retirement rises more in seniority-pay districts (estimate of *t ≥ year of CBA exp* equal to 8.7 percentage points and of *t ≥ year of CBA ext* equal to 1.4 percentage points, column 3, p-values equal to 0.001 and 0.39) compared with flexible-pay districts (0.14 and 1.9 percentage points, column 2, p-values equal to 0.97 and 0.46 respectively).

Lastly, columns 2 and 3 of Table IV show estimates of equation 7 separately for teachers with value-added in the top 25 ("high") and bottom 75 percent ("low") of the national distribution. Retirement rates in 2011 increase more for low value-added teachers (with an estimate of *t = 2011* equal to 13.4 percentage points, column 4, significant at 1 percent) than for high value-added teachers (6.5 percentage points, column 4, significant at 1 percent). Also after the expiration of a CBA or its extension, retirement rises slightly more in seniority-pay districts (estimate of *t ≥ year of CBA exp* equal to 6.2 percentage points and of *t ≥ year of CBA ext* equal to 3.1 percentage points, column 3, significant at 10 percent) compared with flexible-pay districts (7.2 and 1.5 percentage points, column 2, p-values equal to 0.01 and 0.53 respectively).

Taken together, these estimates indicate that the timing of the increase in retirement rates following Act 10 matches both the decline in net pay triggered by the increase in the rate of employee contributions to the pension fund and the decline in gross salaries and pension ben-

efits after the expiration of districts' CBAs. This indicates that teachers respond vigorously to changes in both types of compensation. In the following section I use a theoretical framework to better quantify these responses.

6 Retirement In a Life-Cycle Model

The retirement responses to the different compensation changes introduced by Act 10 suggest a large role for changes in salaries and pensions in determining workers' retirement decisions. To better quantify these retirement responses and explore the role of income and substitution effects, this section presents a simple life-cycle model. The model illustrates the relationship between salaries, pensions, and retirement and provides the theoretical grounding for the estimation of the retirement elasticities to salaries and pensions and of the income and substitution effects. The model also serves 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 under certainty illustrated by Blundell and MaCurdy (1999). Each worker maximizes a time-separable utility which depends on consumption C_t (whose price is normalized to 1), leisure L_t, and observable factors X_t, 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: $L_t = 0$ if the individual works (earning an annual salary W_t and paying a pension contribution τ_t), and $L_t = 1$ if the individual is retired (receiving an annual benefit B_t). I also assume that retirement is an absorbing state: if $L_t = 1$, $L_s = 1 \; \forall s > t$. Lastly, individuals discount the future at a rate β and live until period T.

The utility maximization problem of a worker can be expressed as follows:

$$\max_{\{C_s, L_s\}_{s=t}^{T}} \quad U(t) = \sum_{s=t}^{T} \beta^{s-t} U(C_s, L_s, X_s) \tag{8}$$

$$\text{s. t.} \quad A_{t+1} = (1 + r_t)(A_t + W_t(1 - \tau_t)(1 - L_t) + B_t Lt - C_t) \tag{9}$$

where A_t are asset holdings at the beginning of period t. It is useful to write this maximization

problem using a dynamic programming representation:

$$V_t(A_t) = \max_{\{C_s, L_s\}_{s=t}^{T}} U(C_t, L_t, X_t) + \beta V_{t+1}(A_{t+1}) \quad (10)$$
$$\text{s.t. } (9)$$

Given the discreteness of the leisure decision, and denoting

$$V_t^{ret}(A_{t+1}) = \max_{\{C_s\}_{s=t+1}^{T}} \sum_{s=t+1}^{T} \beta^{s-t} U(C_s, 1, X_s)$$

as the continuation value of an individual who chooses to retire in t, the first-order conditions of the problem are as follows:

$$U'_C(C_t, L_t) = \lambda_t(1 + r_t) \quad (11)$$
$$L_t = 1 \quad \text{if } U(C_t, 1, X_t) + \beta V_{t+1}^{ret}(A_{t+1}) - U(C_t, 0, X_t) - \beta V_{t+1}(A_{t+1}) \quad (12)$$
$$+\lambda_t(1 + r_t)(B_t - W_t(1 - \tau_t)) \geq 0$$

where λ_{t+1} is the Lagrange multiplier on the budget constraint, and it represents the marginal utility of wealth. It is also useful to write the budget constraint in (9) in the following way:

$$C_t + (W_t(1 - \tau_t) - B_t)L_t = \Delta A_{t+1} + W_t(1 - \tau_t)$$

where $\Delta A_{t+1} = A_{t+1}/(1+r_t) - A_t$. The left-hand side of this equation shows total expenditure in consumption and leisure; when the price of consumption is normalized to 1, the price of leisure is $W_t(1 - \tau_t) - B_t$. The right-hand side shows instead the individual's "full income" as defined by Blundell and MaCurdy (1999).

The dynamic programming formulation of the model allows me to write the following Euler equation:

$$\lambda_t = \beta(1 + r_t)\mathbb{E}_t\left[\lambda_{t+1}\right] \quad (13)$$

Together with equations (11) and (12), the Euler equation characterizes the optimal consumption and leisure choices. In this framework, the multiplier λ_t represents a sufficient statistic for the allocation of wealth across periods; in other words, variables such as future salaries, pension benefits, or personal characteristics only affect the consumption and retirement decisions in t via λ_t (Blundell and MaCurdy, 1999). Given these optimality conditions, the retirement choice

can be expressed as a function of the price of leisure $W_t(1-\tau_t) - B_t$, the multiplier λ_t, and individual characteristics X_t via a Frisch demand function:

$$Pr(L_t = 1) = L(W_t(1-\tau_t) - B_t, \lambda_t, X_t) \tag{14}$$

It should be noted that, if there is no uncertainty and future variables can be perfectly known at t, equation (13) can be solved iteratively, yielding

$$\ln \lambda_t = \sum_{s=t_0}^{t} b_s + \ln \lambda_{t_0}$$

where $b_s = -\ln \beta(1+r_s)$. This matters for estimation: If one is interested in the elasticities of retirement to salaries and pensions holding the marginal utility of wealth (i.e., λ_t) constant – also known as Frisch elasticities – in estimation λ_t can be captured by an individual fixed effect and an age polynomial.

Income and Substitution Effects Before proceeding to the estimation of the retirement elasticities to salaries and pensions, it is useful to decompose the retirement responses to changes in these variables into income and substitution effects. The substitution effect implies that, when the price of one good increases, the individual will consume less of that same good. It follows that an increase in net salaries $W_t(1-\tau_t)$ (which causes an increase in the price of leisure) should lead to a decline in the probability of retirement, whereas an increase in pension benefits B_t (which causes a decline in the price of leisure) should lead to an increase in this probability. The income effect, on the other hand, implies that consumption of any normal good will increase if the individual's lifetime income increases. If leisure is a normal good, retirement should increase whenever either net salaries or pension benefits increase, because the individual will be richer.

To summarize, a decline in net salaries (such as the one that followed the passage of Act 10 in 2011) should trigger a negative income effect and a positive substitution effect on retirement, with an overall effect that is ambiguous in sign. A decline in pension benefits (such as the one that followed districts' CBA expirations), on the other hand, should generate negative income and substitution effects and unambiguously decrease retirement.

6.2 Estimating Income and Substitution Effects of Salaries and Retirement Benefits

The event studies in Section 5 indicate that both the fall in net salaries that followed Act 10 and the fall in gross salaries and pension benefits that followed the expiration of CBAs led to an increase in retirement. This suggests large substitution effects and possibly small income effects. I now use the structure provided by the theoretical framework to estimate bounds and point estimates of income and substitution effects of changes in salaries and pensions.

In the theoretical framework above, the substitution effect is captured by the Frisch semi-elasticity of substitution (as in Chetty et al., 2011), defined as the semi-elasticity of retirement to the price of leisure holding the marginal utility of wealth constant: $\frac{\partial Pr(L_t=1)}{\partial \ln W_t(1-\tau_t)-B_t}|_{\lambda_t}$ (where $Pr(L_t = 1)$ is defined as in equation (14)). To make progress on estimation, I linearize equation (14) as follows:

$$Pr(L_{it} = 1) = \hat{\xi}^s \left[W_t(1 - \tau_t) - B_t\right] + \hat{\xi}^y \lambda_{it} \hat{\Gamma}(X_{it}) + \hat{\varepsilon}_{it} \tag{15}$$

where the subscript i denotes the individual and t denotes time. As before, $W_t(1-\tau_t) - B_t$ is the price of leisure, and $\hat{\Gamma}(X_{it})$ is a function of individual observable characteristics. In this specification $\hat{\xi}^s$ represents the Frisch semi-elasticity of intertemporal substitution. The parameter $\hat{\xi}^y$ captures instead the way in which changes the marginal utility of wealth, triggered by changes in in lifetime income, affect retirement; as such, it represents the income effect.

Substitution Effect: Lower Bound The challenge in estimating equation (15) is that λ_{it} is unobserved. To make progress on estimation, it is useful to express the marginal utility of wealth in t as a function of the net present value of future salaries and pensions, which in turn depend on salaries and pensions in t: $\lambda_t = G(W_t(1 - \tau_t), B_t, X_t)$. One can then re-write equation (15) as follows:

$$Pr(L_{it} = 1) = \beta \ln \left[W_{it}(1 - \tau_t)\right] + \gamma \ln B_{it} + \Gamma(X_{it}) + \varepsilon_{it} \tag{16}$$

where i denotes the individual, t denotes time, W_{it} is wage and B_{it} are pension benefits. The function $\Gamma(X_{it})$ controls for observable determinants of the retirement decision, including age, experience, district, and gender fixed effects. In this equation, the parameter β captures the retirement effect of changes in net salaries, and the parameter γ captures the effect of changes in benefits.

As explained above, the sign of the estimate for γ should be positive, since income and substitution effects of pension benefits on retirement have the same sign. The point estimate of

γ therefore represents an upper bound to the income effect. The sign of β, on the other hand, is ambiguous. If β is negative, the substitution effect overcomes the income effect, and the point estimate can be interpreted as a lower bound on the substitution effect. If instead β is positive, the income effect overcomes the substitution effect and the point estimate can be interpreted as a lower bound on the income effect.

A necessary assumption for the consistent estimation of the parameters β and γ in equation (16) is that the unobserved component of retirement ε_{it} is mean independent of salaries and retirement benefits. Salaries and benefits, however, can be correlated with unobserved individual characteristics that also directly affect retirement, creating a problem of endogeneity. To address this issue I use 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 this IV strategy are as follows:

$$\begin{aligned} \ln W_{it}(1-\tau) &= \alpha_1^w \ln(1-\tau_t) + \alpha_2^w \mathbb{1}(t \geq Exp_j) + \alpha_3^w e_{it}\mathbb{1}(t \geq Exp_j) + \alpha_4^w \mathbb{1}(t \geq Ext_j) \quad (17) \\ &\quad + \alpha_5^w e_{it}\mathbb{1}(t \geq Ext_j) + \omega_{it}^w \\ \ln B_{it} &= \alpha_1^b \ln(1-\tau_t) + \alpha_2^b \mathbb{1}(t \geq Exp_j) + \alpha_3^b e_{it}\mathbb{1}(t \geq Exp_j) + \alpha_4^b a_{it}\mathbb{1}(t \geq Exp_j) \quad (18) \\ &\quad + \alpha_5^b \mathbb{1}(t \geq Ext_j) + \alpha_6^b e_{it}\mathbb{1}(t \geq Ext_j) + \alpha_7^b a_{it}\mathbb{1}(t \geq Ext_j) + \omega_{it}^b \end{aligned}$$

where a_{it} and e_{it} are the individual's age and experience in t. Estimates of β and γ are shown in Table V. In all specifications I control for an indicator for the year 2011, to account for a potential increase in retirement driven by teachers being upset about Act 10 as a whole. Both OLS and 2SLS estimates of β are negative, indicating a substitution effect of salaries that is larger than the income effect. The baseline OLS estimate of β is equal to -0.380; this indicates that a ten-percent reduction in net salaries induces a 3.8 percentage points increase in retirement, or 22 percent compared with an average pre-2011 retirement rate of 17 percent (Table V, column 1, significant at 1 percent). This estimate is even larger when excluding 2011 in estimation (column 2). As expected, estimates of γ are instead positive, ranging from 0.335 (column 3) to 0.345 (column 4).

2SLS estimates of β are significantly larger than OLS. A ten-percent reduction in net salaries triggers a 14.8 percentage points increase in retirement, or 87 percent (Table V, column 1, significant at 1 percent). Interpreted as a lower bound on the substitution elasticity, this estimate implies a rather large substitution effect.

Income Effect: Upper Bound The point estimate of γ is interesting in itself: given that income and substitution effects of retirement benefits have the same sign on retirement, this point estimate represents an upper bound on the income effect. This point estimate, equal to 0.459, implies that a ten-percent decline in retirement benefits leads to a 4.6 percentage points decline in retirement, or 27 percent. Compared with other estimates in the literature, this estimate suggests a moderate income effect, smaller than the substitution effect found above.

The magnitude of this estimate also suggests that the income and substitution effects of salaries and pensions are actually different and that individuals respond more to changes in salaries than they do to changes in pension benefits. In fact, if the magnitudes of the income (I) and and substitution (S) effects of salaries and pensions were the same, then $\beta = -S + I$ and $\gamma = S + I$. This implies $|\beta| \leq |\gamma|$. The estimates in Table V contradict this statement ($|\beta| = 1.45$ and $|\gamma| = 0.46$ in column 3). This finding is important because it suggests that policies that affect different types of teacher compensation might have very different effects on their behavior. I quantify this more precisely in the next section, studying the retirement responses to an alternative compensation policy.

Estimates by Subgroups Table VI shows estimates of β and γ by gender. Both γ and β are larger in magnitude for women, although not statistically distinguishable from those of men. Figure X shows estimates of γ and β separately by two-years age classes. The substitution effect is smaller in magnitude for younger teachers (for example, γ is equal to -0.43 for 56-years-olds, with a p-value of 0.54), and it increases with age, reaching -1.290 for teachers who are 66 years old or older (with a p-value of 0.04, Figure X, top panel). The magnitude of the upper bound on the income effect of retirement benefits is also larger for older teachers (for example, β is equal to 0.435 for 56-years-olds and 0.922 for 62-years-olds, Figure X, bottom panel). Finally, Figure XI shows estimates by five-years experience classes. Estimates of both β and γ are larger in magnitude for more experienced teachers. Overall, these estimates suggest that older and more experienced teachers respond more to changes in salaries and in retirement benefits.

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 choose to retire.

Estimates of these elasticities, however, 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 active workers who are close enough to the retirement margin, a change in current compensation is more salient, or at least valued differently, than a change in retirement benefits that are to be received in the future.

This last finding is important for policy design. Teachers' lifetime compensation schemes in several US states are designed in a way that backloads pay into the future and after retirement; in other words, these workers receive pensions that are relatively more generous than salaries compared to the majority of other professions (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 in theory have significant effects on the decision of teachers to retire at a given age, and in turn on the composition of the teaching workforce.

To test this hypothesis, in this section I use the elasticities to net salaries and retirement benefits estimated above to evaluate the effects of an alternative budget-cutting policy. In particular I consider a policy which, in the medium run, 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 (and a subsequent decline in net salaries). I study the effects of this policy on retirement rates and on the composition of the pool of retiring teachers with respect to a range of observable characteristics.

7.1 An Alternative Budget-Cutting Policy

To understand how this alternative policy works, it is useful to quantify how much money the state of Wisconsin was able to save with the introduction of employees' contribution to the pension fund. The solid line in Figure XII 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 a much lower retirement rate than the one that followed 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 $\hat{\Gamma}(X_{it})$ are the 2SLS estimates of the parameters in equation (16); $\hat{\beta}$ and $\hat{\gamma}$ are shown in column 3 of Table V.

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 XII 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 contributions by the year 2022.

7.2 Retirement Under The Alternative Policy

Figure XIII (top 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. Starting from 2011, retirement rates are however much lower under the alternative policy. Under this policy retirement still increases in 2011 (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 only to 29.3 percent, rather than to 32.9 under Act 10. Retirement rates are also lower, under the alternative policies, in 2012-2015, and equal to 10.0 percent in 2012 (compared with 21.1 percent under Act 10) and 9.0 percent in 2015 (compared with 21.3 percent).

Composition of The Pool of Retiring Teachers The middle panel of Figure XIII shows average age and experience of teachers who retire under Act 10 and under the alternative policy. Average age at retirement is higher under the alternative policy, and equal to 60.6 in 2012 and 61.6 in 2015, compared with 59.6 and 59.9 under Act 10 respectively. Average experience of teachers who decide to retire is also higher under the alternative policy, and equal to 29.0 in 2012 and 28.9 in 2015 compared with 26.8 and 26.2 under Act 10.

The bottom panel of Figure XIII shows average value-added of teachers who retire under Act 10 and under the alternative policy. While retirees' value-added remains fairly stable after Act 10 compared with before (and equal to 0.008 in 2010 and 0.011 in 2013), it falls slightly under the alternative policy, to -0.003 in 2013 and -0.004 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 devoted to changes in salaries. This is in spite of the fact that teachers 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. In spite of this, to date we have little

evidence on how pension schemes affect teachers' labor supply and retirement choices, especially compared with salaries, and how teachers trade off salaries against pensions in making these choices.

This paper attempts to fill this gap by exploiting a reform which contemporaneously changed salaries and pensions Wisconsin public school teachers. Leveraging the staggered timing of these changes across districts, I study the retirement responses to changes in salaries and pensions of public school teachers, with the ultimate goal of learning how distributing compensation over a worker's lifetime affects the composition of the workforce. Reduced-form evidence on the timing of retirement indicates that teachers respond to both a decline in net salaries and a decline in net future pension benefits by becoming more likely to retire.

To learn more about teachers' preferences I use a simple lifecycle model to derive a retirement demand 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. An elasticity of retirement with respect to changes in net salaries equal to -0.87 indicates that the substitution effect of salaries dominates over the income effect. This estimate can also be interpreted as a lower bound on the intertemporal substitution (or Frisch) elasticity, and indicates a large substitution effect compared with other estimates in the literature (i.e., Gelber et al., 2016). The elasticity of retirement with respect to changes in pension benefits, on the other hand, is positive and equal to 0.27, which suggests a more muted income effect.

Importantly, these elasticities also indicate that teachers respond differently to changes in salaries and changes in pension benefits: In particular, they value one dollar of salaries more than one dollar of pensions. This finding 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: District characteristics and CBA expiration dates: Logit, dependent 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. $^{**} \leq 0.1$, $^{**} \leq 0.05$, $^{***} \leq 0.01$.

Table II: 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 III: Salaries and pensions in the aftermath of Act 10. OLS, dependent variable is log(gross salary), log(net salary), log(pension benefits)

	Gross salary		Net salary		Pension Benefits	
	(1)	(2)	(3)	(4)	(5)	(6)
after Act 10	-0.0213**	-0.0215**	-0.0807***	-0.0810***	-0.0064	-0.0067
	(0.0095)	(0.0102)	(0.0093)	(0.0102)	(0.0088)	(0.0095)
after CBA expiration	-0.0335***	-0.0078	-0.0407***	-0.0082	-0.0162**	0.0054
	(0.0089)	(0.0104)	(0.0086)	(0.0104)	(0.0077)	(0.0088)
after CBA extension		-0.0311***		-0.0395***		-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	0.59	0.60	0.63	0.63	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

		By type of district		By value-added	
	(1)	(2)	(3)	(4)	(5)
		Flexible pay	Seniority pay	High	Low
t = 2011	0.0780***	0.1828***	0.0706***	0.0653***	0.1339***
	(0.0172)	(0.0400)	(0.0112)	(0.0171)	(0.0309)
t > 2011	-0.0592***	0.0345	-0.0412**	-0.0177	-0.0028
	(0.0182)	(0.0400)	(0.0188)	(0.0266)	(0.0349)
t ≥ year of CBA exp	0.0955***	0.0014	0.0863***	0.0722***	0.0617*
	(0.0250)	(0.0451)	(0.0256)	(0.0276)	(0.0353)
t ≥ year of CBA ext	0.0188	0.0189	0.0139	0.0154	0.0308*
	(0.0133)	(0.0252)	(0.0161)	(0.0244)	(0.0170)
District FE	Yes	Yes	Yes	Yes	Yes
Exp, Exp ^{2}	Yes	Yes	Yes	Yes	Yes
Age, Age^2	Yes	Yes	Yes	Yes	Yes
Pre-Act10 ret. rate	0.166	0.168	0.166	0.177	0.135
N	69348	26174	37679	3540	11882
Clusters (districts)	211	74	90	148	209
R-squared	0.08	0.09	0.07	0.14	0.12

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 and quadratic polynomials in age and experience. The sample is restricted to districts with non-missing CBA expiration dates and to retirement-eligible teachers. Column 2 is estimated on the sample of teachers in flexible-pay districts; column 3 is estimated on the sample of teachers in seniority-pay districts; column 4 is estimated on the sample of teachers with value-added in the top quartile of the national distribution; and column 5 is estimated on teachers in the bottom three quartiles of the same distribution. Standard errors in parentheses are clustered at the district level. ** ≤ 0.1, ** ≤ 0.05, *** ≤ 0.01..

Table V: Bounds for The Income and Substitution Effects. OLS and IV, Dependent Variable Equals 1 if a Teacher Retires At The End of The Year

	OLS		2SLS	
	(1)	(2)	(3)	(4)
$\ln[W_t(1-\tau_t)]$	-0.380***	-0.410***	-1.478***	-1.644***
	(0.047)	(0.047)	(0.525)	(0.492)
$\ln B_t$	0.335***	0.345***	0.459***	0.460***
	(0.035)	(0.033)	(0.060)	(0.077)
District FE	Yes	Yes	Yes	Yes
Age, exp FE	Yes	Yes	Yes	Yes
Excl. 2011	No	No	No	Yes
KP F-stat			13.12	11.55
Pre-Act10 ret. rate	0.17	0.17	0.17	0.17
N	68100	59472	68100	59472
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 (17). 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 and for age, experience, and district fixed effects; columns 2 and 4 exclude observations for the year 2011. Standard errors in parentheses are clustered at the district level. $^{**} \leq 0.1$, $^{**} \leq 0.05$, $^{***} \leq 0.01$.

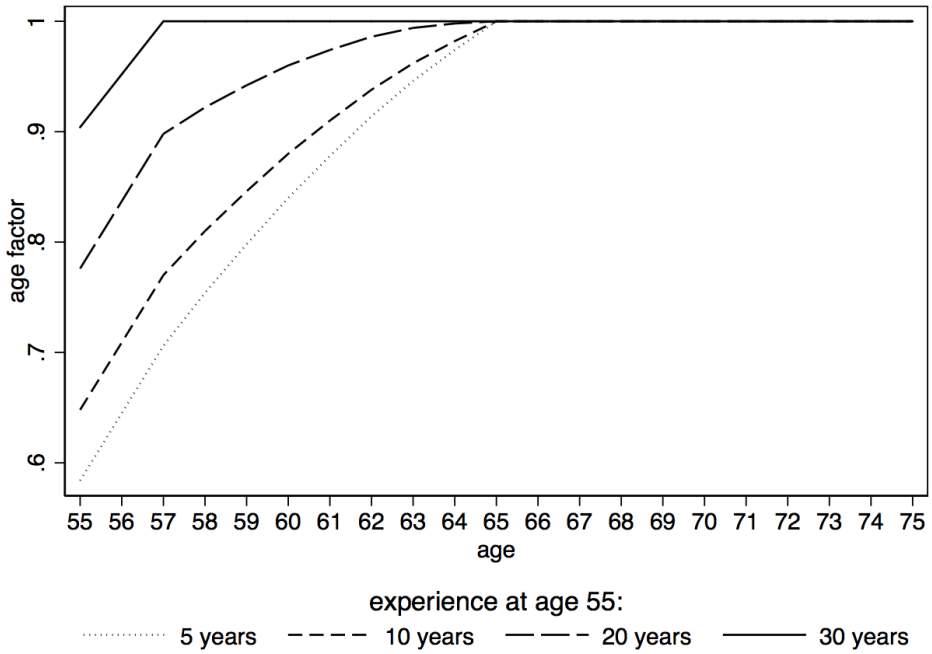
Table VI: Bounds for The Income Effects by Gender. OLS and IV, Dependent Variable Equals 1 if a Teacher Retires At The End of The Year. Estimates by Gender

	Female		Male	
	(1) OLS	(2) 2SLS	(3) OLS	(4) 2SLS
$\ln[W_t(1-\tau_t)]$	-0.367***	-1.606***	-0.432***	-1.035*
	(0.050)	(0.596)	(0.056)	(0.587)
$\ln B_t$	0.330***	0.488***	0.356***	0.425***
	(0.037)	(0.066)	(0.044)	(0.081)
District FE	Yes	Yes	Yes	Yes
Age, exp FE	Yes	Yes	Yes	Yes
KP F-stat		10.57		3.84
Pre-Act10 ret. rate	0.16	0.16	0.19	0.19
N	51847	51847	16253	16253
Clusters (districts)	211	211	210	210

Note: The dependent variable equals one if a retirement-eligible teacher exits at the end of the academic year. Columns 1 and 3 estimate OLS; columns 2 and 4 estimate 2SLS, using the first stage in equation (17). 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 and for age, experience, and district fixed effects. Columns 1 and 2 are estimated on the subsample of female teachers, and columns 3 and 4 are estimated on the subsample of male teachers. Standard errors in parentheses are clustered at the district level. $^{**} \leq 0.1$, $^{**} \leq 0.05$, $^{***} \leq 0.01$.

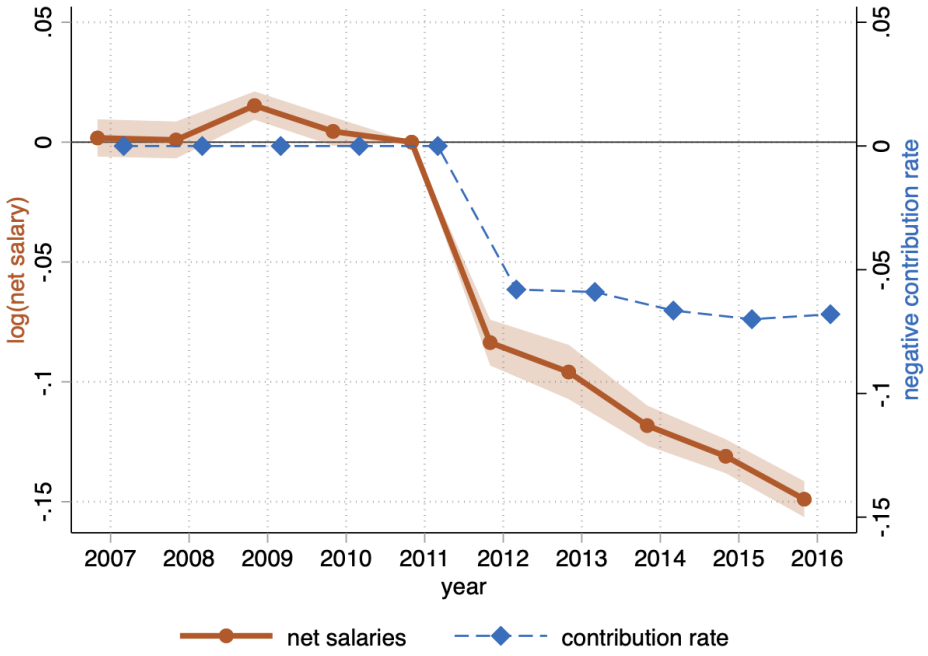
Figures

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



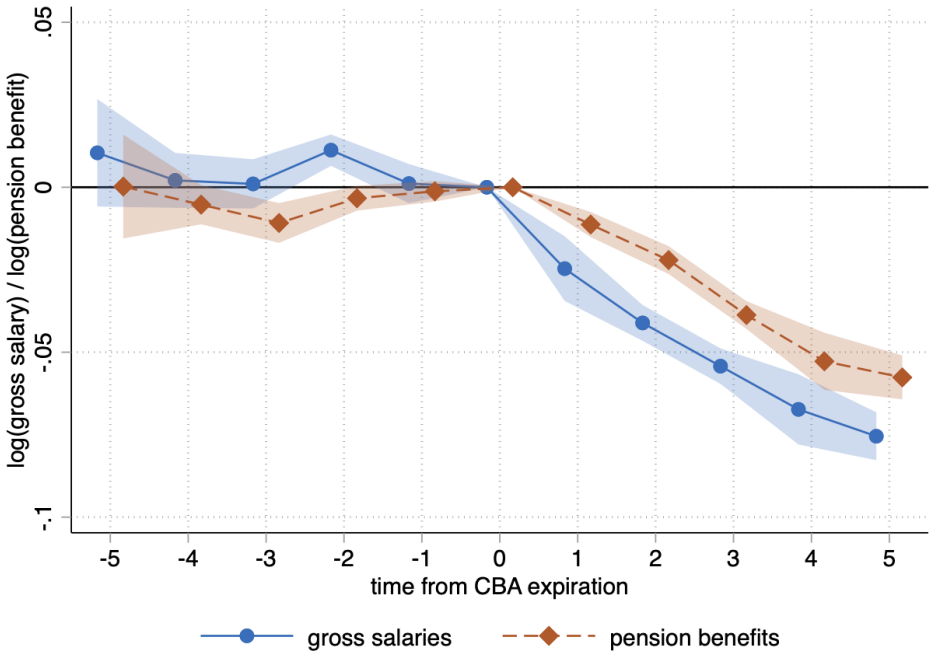
Note: The figure plots the actuarial reduction factor π used in teachers' pension formula, by age and separately for teachers with 5, 10, 20, and 30 years of experience by age 55.

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.

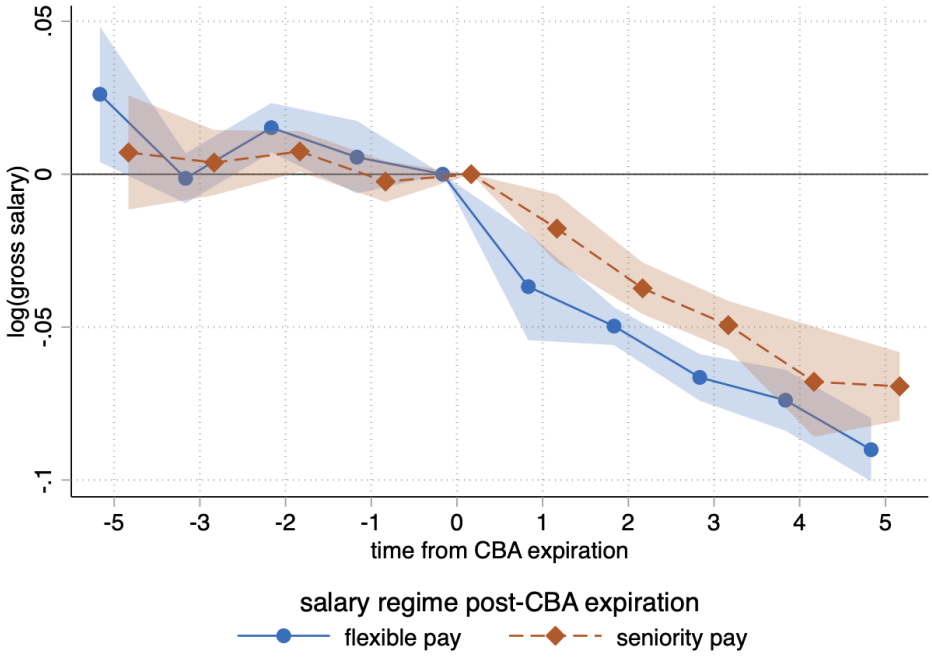
Figure III: Teachers' gross salaries and pension benefits: Event study



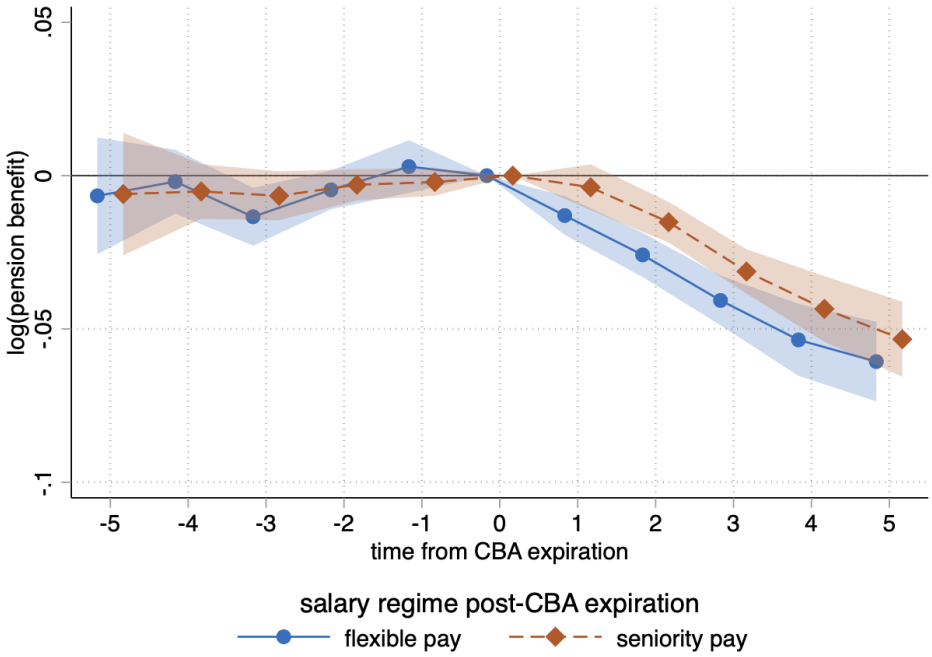
Note: The figure shows an event study of gross salaries (solid line) and pension benefits (dashed line), conditional on experience, education, and district effects, in the years around the expiration of each district's pre-existing CBA. Each series shows the OLS point estimates and the 90 percent confidence 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

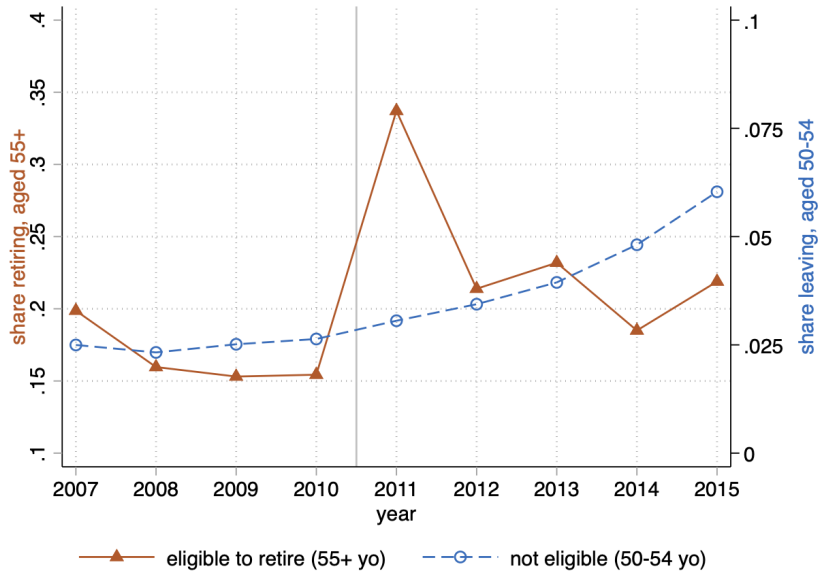


Panel B: Pension benefits



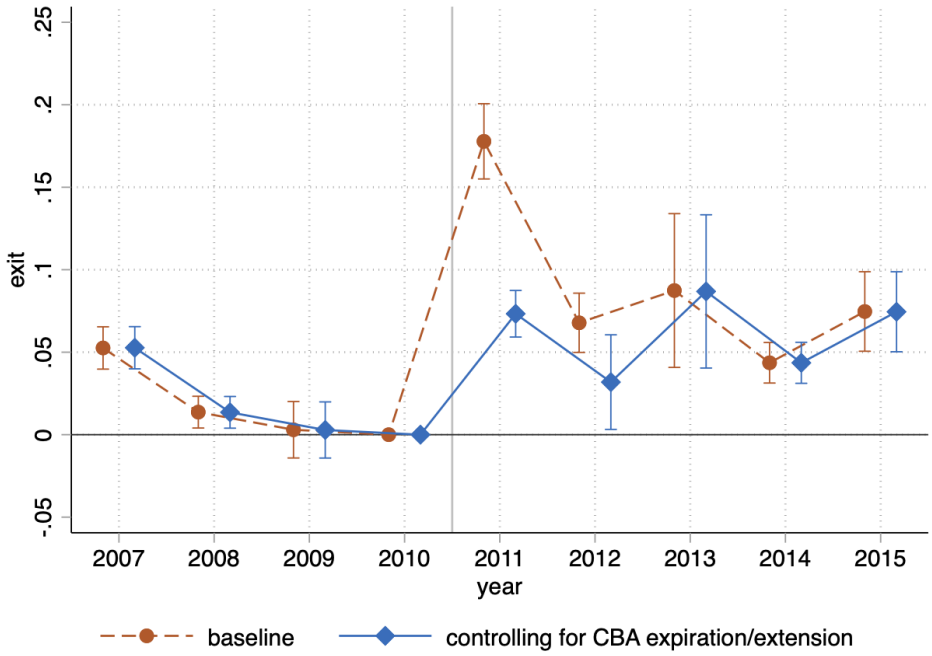
Note: The figure shows an event study of gross salaries (Panel A) and pension benefits (Panel B), conditional on experience, education, and district effects, in the years around the expiration of each district's pre-existing CBA and separately for flexible-pay (solid line) and seniority-pay districts (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 are clustered at the district level.

Figure V: Exit Rates, By Retirement Eligibility



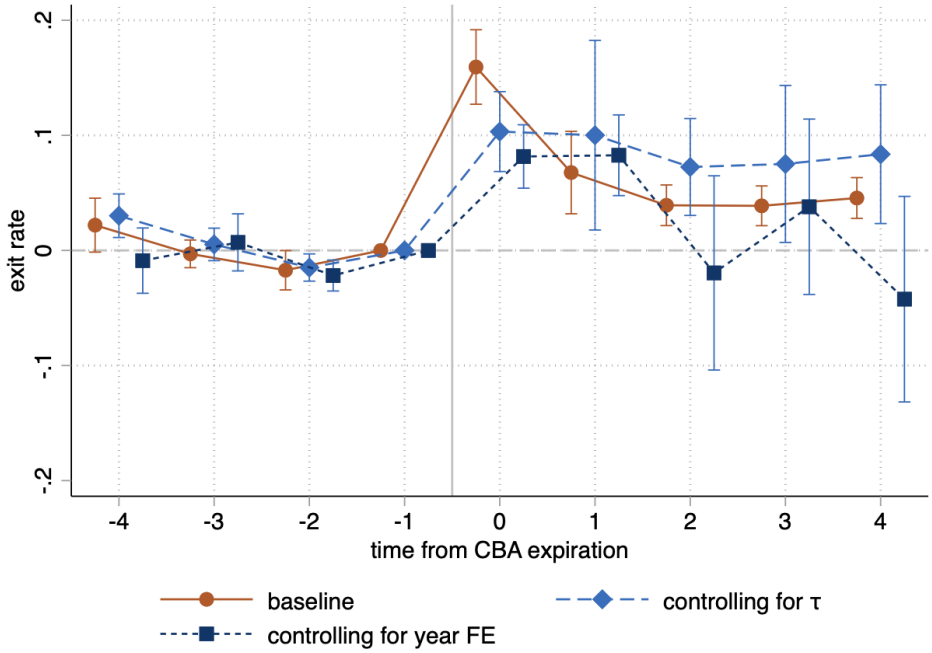
Note: Share of teachers exiting Wisconsin public schools, by retirement eligibility. Sample restricted to teachers aged 50-70 with at least 5 years of experience.

Figure VI: Event Study: Teacher Retirement Around Act 10



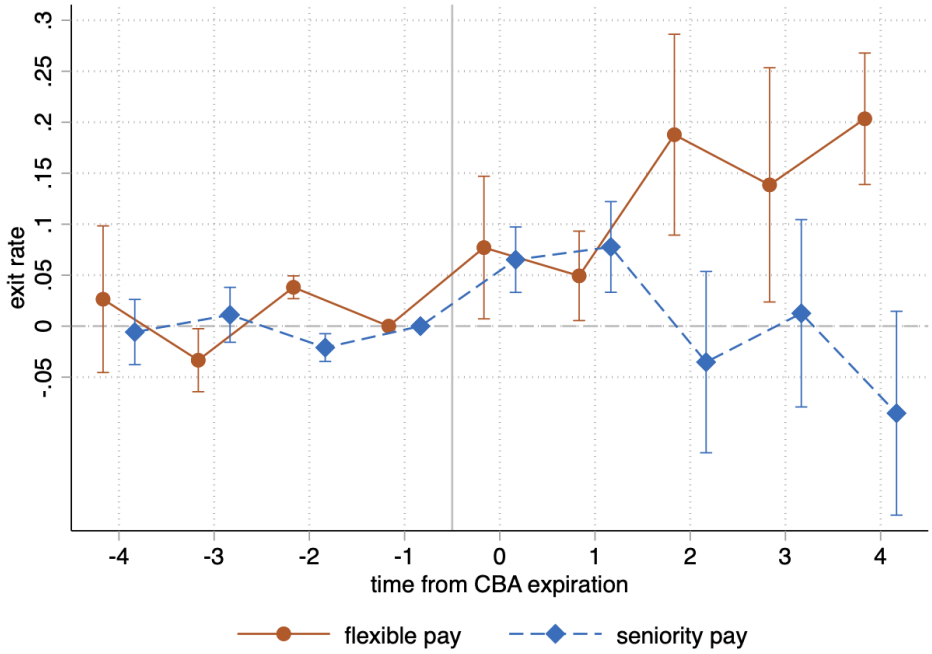
Note: The figure shows an event study of retirement rates conditional on experience, age, gender, and district fixed effects, in the years around the passage of Act 10 in 2011. Each series shows the OLS point estimates and the 90 percent confidence intervals of the parameters δ_n in the equation $e_{ijt} = \sum_{n=2007}^{2015} \delta_n \tau_n + \gamma X_{it} + \theta_j + \sum_{n=2007}^{2015} \eta_n \mathbb{1}(n > Exp_j)\tau_n + \varepsilon_{ijt}$, 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



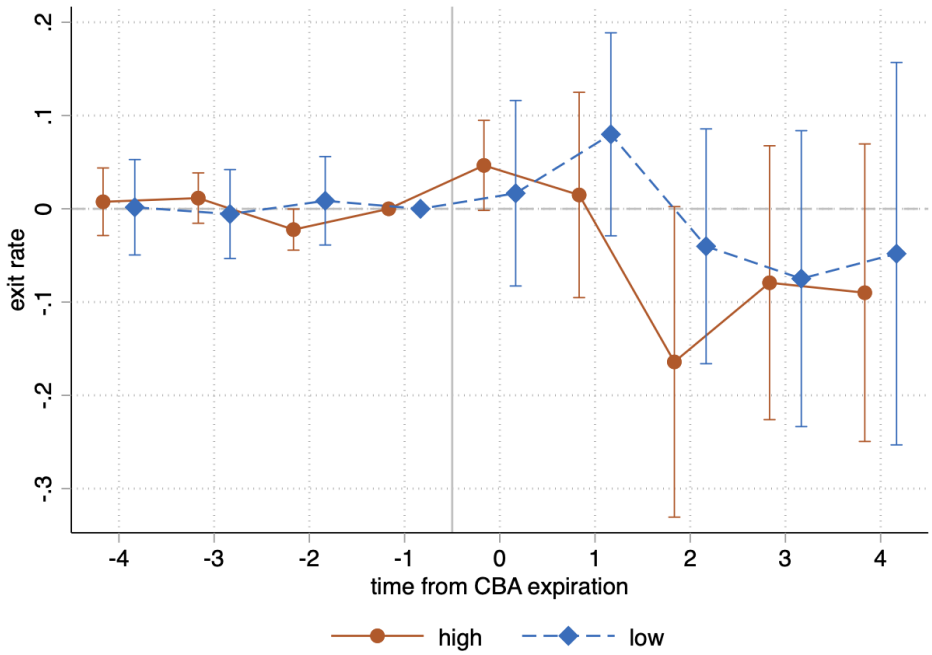
Note: The figure shows an event study of retirement rates conditional on experience, age, gender, and district fixed effects, in the years around the expiration of each district's CBA. Each series shows the OLS point estimates and the 90 percent confidence intervals of the parameters δ_n in the equation $e_{ijt} = \sum_{n=-5}^{5} \delta_n \mathbb{1}(t - Exp_j = n) + \gamma X_{it} + \theta_j + \tau_t + \varepsilon_{ijt}$, 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 dashed series, estimates of δ_n are obtained not controlling for τ_t. Standard errors are clustered at the district level.

Figure VIII: Event Study: Teacher Retirement Around The Expiration of Districts' CBAs. Flexible-Pay vs. Seniority-Pay Districts



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. The solid line shows estimates for flexible-pay districts; the dashed line shows estimates for seniority-pay districts. Standard errors are clustered at the district level.

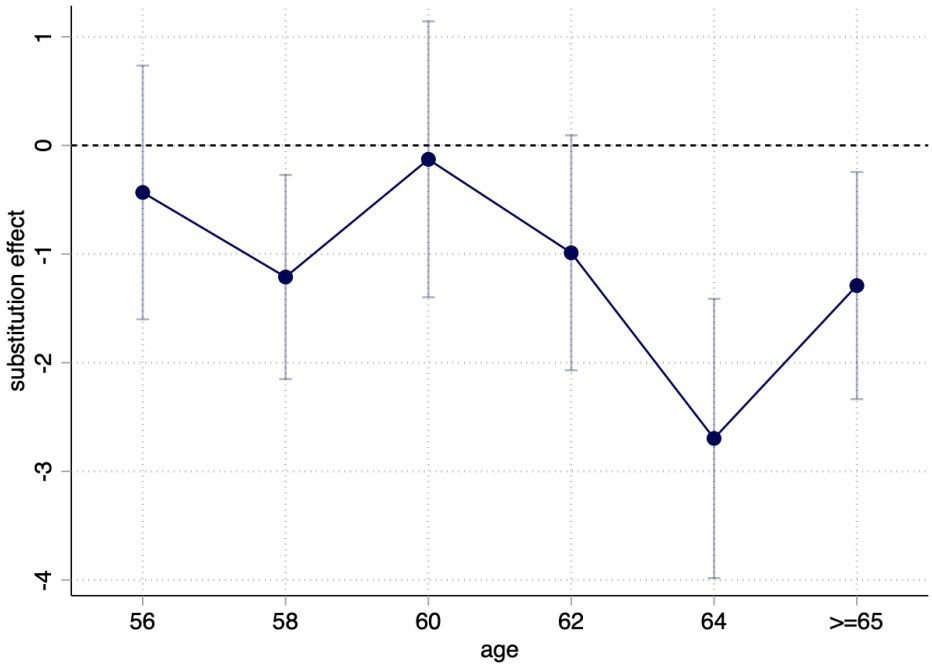
Figure IX: Event Study: Teacher Retirement Around The Expiration of Districts' CBAs. High vs. Low-Value-Added Teachers



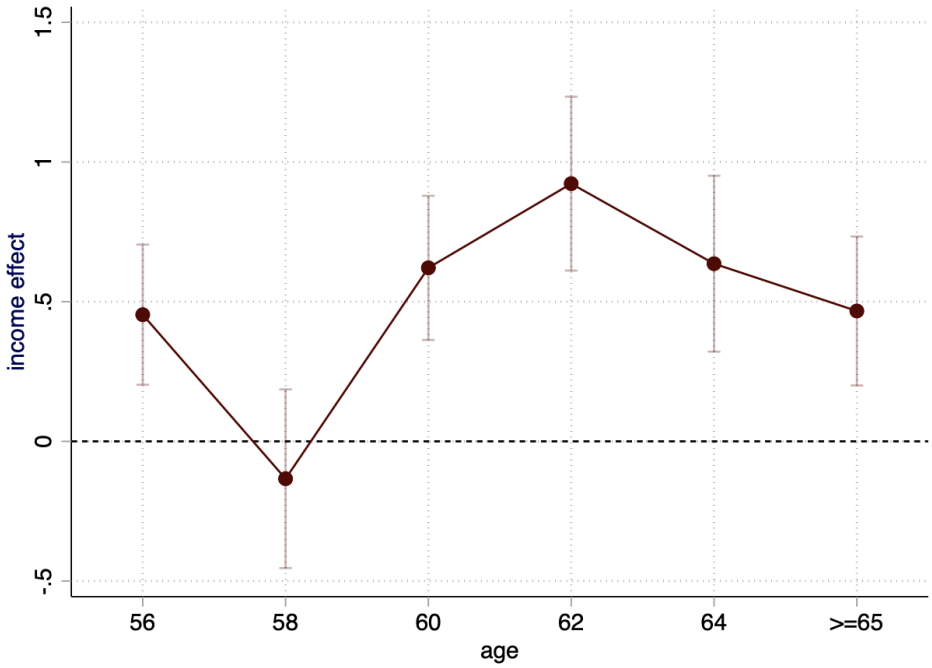
Note: The figure shows an event study of retirement rates conditional on experience, age, gender, and district fixed effects, in the years around the expiration of each district's CBA. Each series shows the OLS point estimates and the 90 percent confidence intervals of the parameters δ_n in the equation $e_{ijt} = \sum_{n=-5}^{5} \delta_n \mathbb{1}(t - Exp_j = n) + \gamma X_{it} + \theta_j + \tau_t + \varepsilon_{ijt}$, 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. The solid line shows estimates for teachers with value-added in the top three quartiles of the state distribution; the dashed line shows estimates for teachers in the bottom quartile. Standard errors are clustered at the district level.

Figure X: Elasticities By Age

Panel A): Elasticity to $\ln W_t(1-\tau_t)$ (lower bound on the substitution effect)



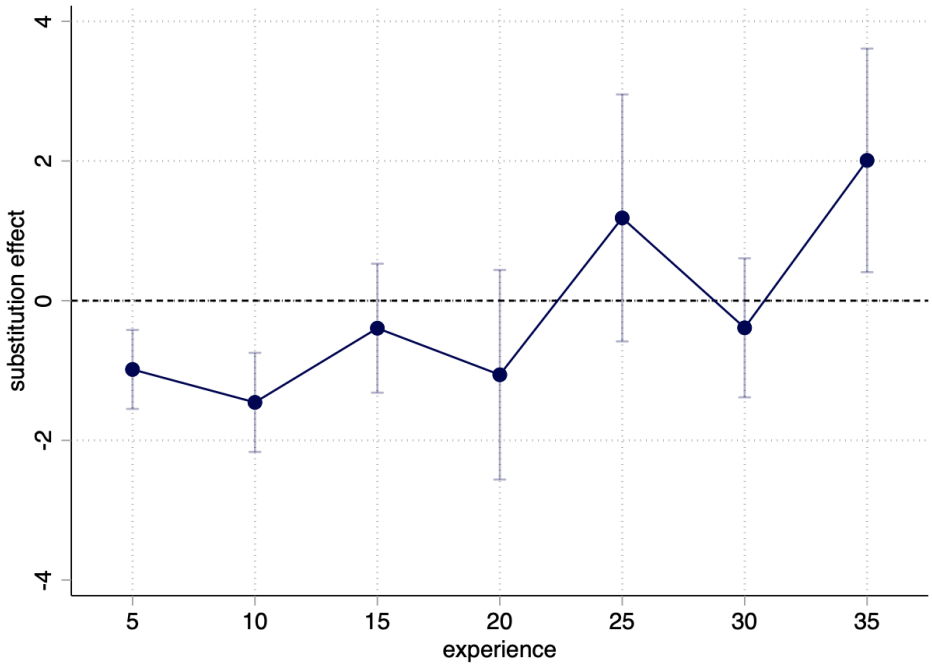
Panel B): Elasticity to $\ln B_{it}$ (upper bound on the income effect)



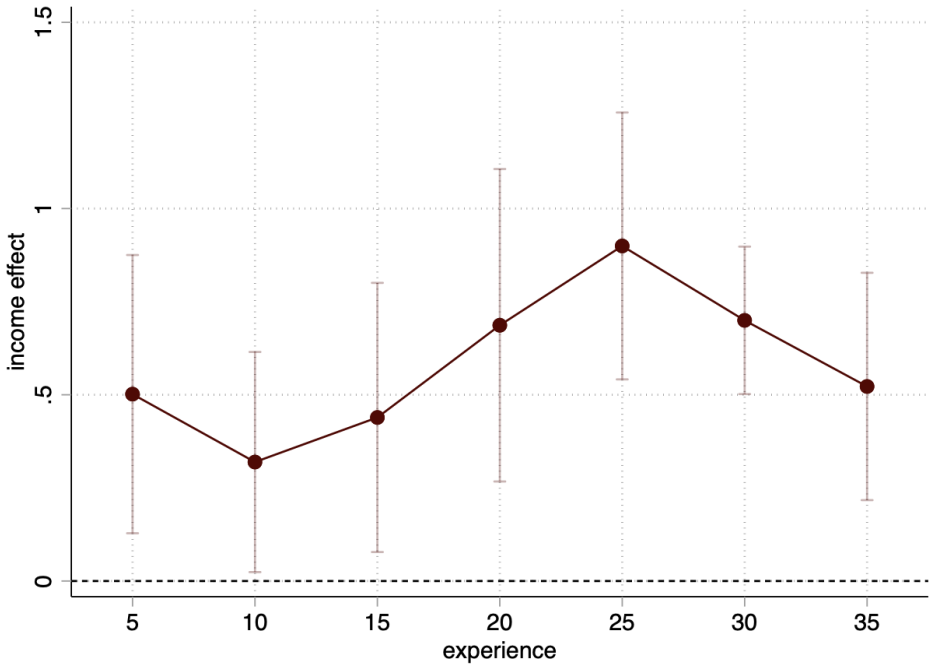
Note: Panel A shows 2SLS estimates and 90 percent confidence intervals of the parameters β_a in the equation $L_{it} = \Gamma(X_{it}) \sum_a \beta_a \ln W_t(1-\tau_t)\alpha_a + \gamma B_{it} + \varepsilon_{it}$, where the variables W_{it} and τ_{it} represent the salary and contribution rate for teacher i in year t, the variable B_{it} represents the pension benefit for a teacher i who retires in year t, and α_a are two-years age fixed effects. The function $\Gamma(X_{it})$ includes controls for the year 2011 and for age, experience, and district fixed effects. Panel B shows 2SLS estimates and 90 percent confidence intervals of the parameters γ_a in the equation $L_{it} = \Gamma(X_{it})\alpha + \beta \ln W_t(1-\tau_t) + \sum_a \gamma_a \ln B_{it}\alpha_a + \varepsilon_{it}$. Standard errors in parentheses are clustered at the district level.

Figure XI: Elasticities By Experience

Panel A): Elasticity to $\ln W_t(1-\tau_t)$ (lower bound on the substitution effect)

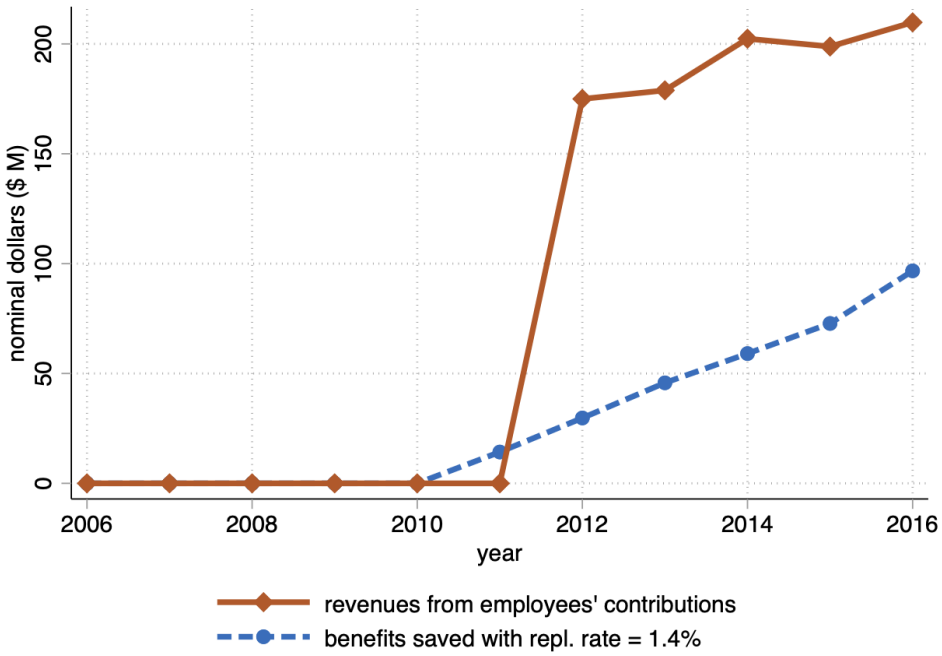


Panel B): Elasticity to $\ln B_{it}$ (upper bound on the income effect)



Note: Panel A shows 2SLS estimates and 90 percent confidence intervals of the parameters β_a in the equation $L_{it} = \Gamma(X_{it}) \sum_e \beta_e \ln W_t(1-\tau_t)\eta_e + \gamma B_{it} + \varepsilon_{it}$, 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 η_e are five-years experience fixed effects. The function $\Gamma(X_{it})$ includes controls for the year 2011 and for age, experience, and district fixed effects. Panel B shows 2SLS estimates and 90 percent confidence intervals of the parameters γ_a in the equation $L_{it} = \Gamma(X_{it})\alpha + \beta \ln W_t(1-\tau_t) + \sum_e \gamma_e \ln B_{it}\eta_e + \varepsilon_{it}$. Standard errors in parentheses are clustered at the district level.

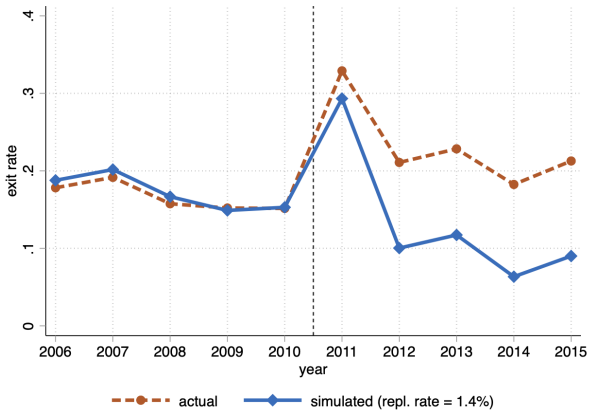
Figure XII: Budget Savings Under Act 10 and Under Counterfactual Policy



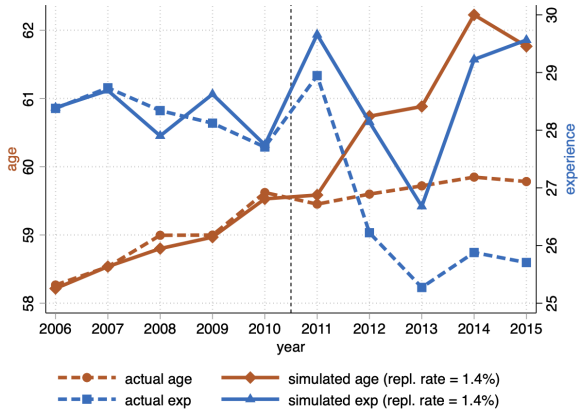
Note: The dashed line shows revenues from employees' contributions to the pension fund, for all Wisconsin teachers. The solid line shows savings achieved with the alternative budget-cutting policy presented in the text, and calculated as $S_{it} = (B_{it} - B'_t) * e'_{it} + B_{it} * (e_t - e'_{it})$ 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 XIII: Retirement Rates and Characteristics of Teachers Who Retire: Act 10 vs. Counterfactual Policy

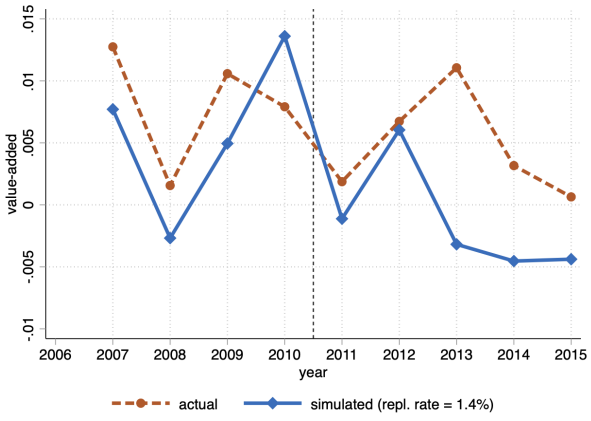
Panel A): Retirement Rates



Panel B): Age and Experience of Teachers Who Retire



Panel A): Value-Added of Teachers Who Retire



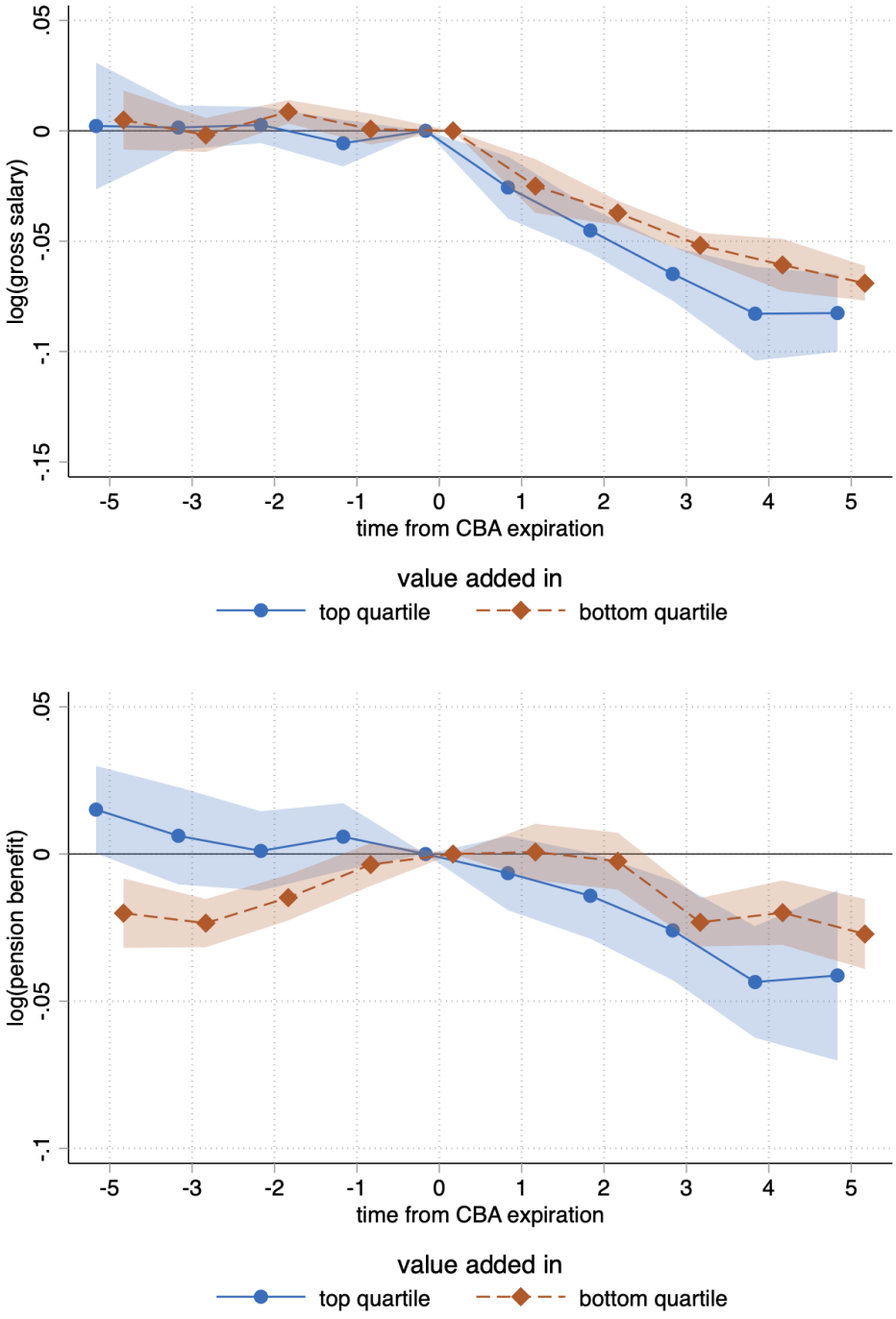
Note: The dashed lines show averages of retirement rates (panel A), age and experience of teachers who retire (panel B) and their value-added (panel B). The solid lines show averages of the same variables under a counterfactual policy which keeps employees's contributions at zero and lowers the retirement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

Appendix

For online publication only

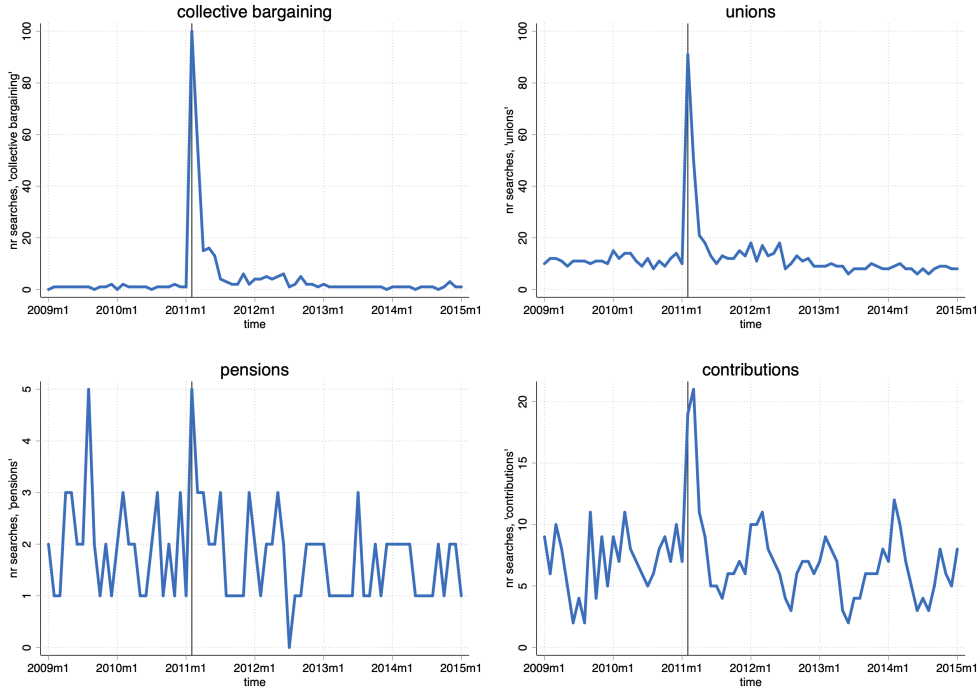
Appendix A Additional Tables and Figures

Figure AI: Teachers' gross salaries and pension benefits: Event study by teacher value-added



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 teachers with value-added in the top (solid line) and bottom quartile (dashed line) of the state distribution. 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.

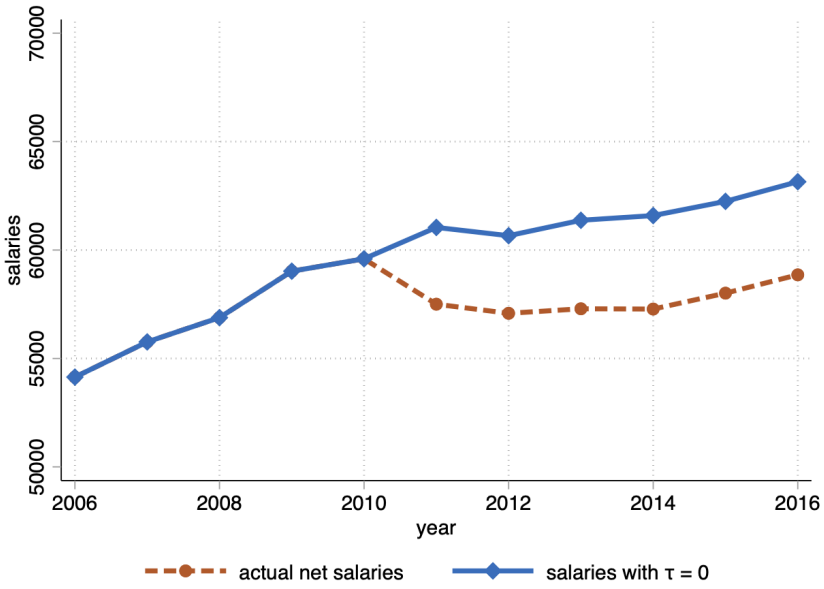
Figure AII: Salience of Act 10 Changes: Google Searches in Wisconsin



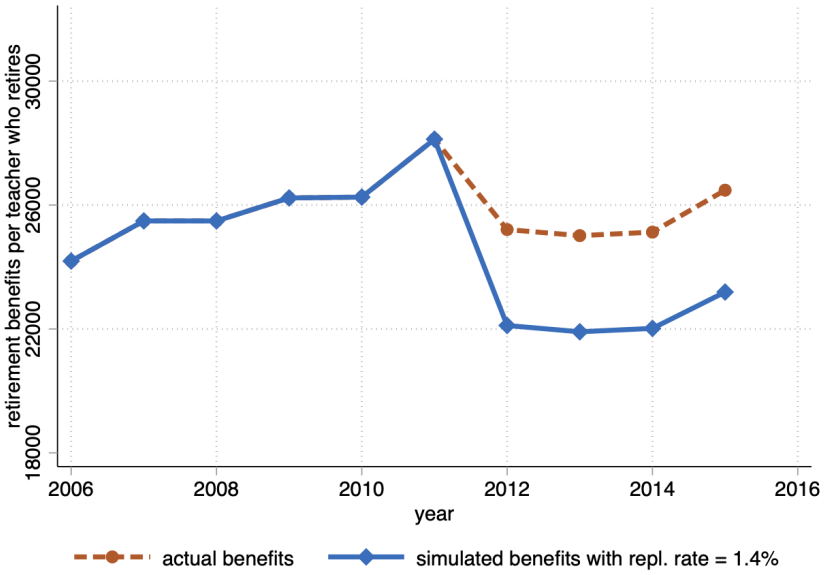
Note: Trends in Google Searches of the terms "collective bargaining," "unions," "pensions," and "contributions" performed from the US state of Wisconsin between 1/1/2009 and 1/1/2015.

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.