The Myth of Unions' Overprotection of Bad Teachers: Evidence from the District-Teacher Matched Panel Data on Teacher Turnover

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Abstract

This study offers a simple two-period job matching model linking teachers unions to both voluntary and involuntary teacher turnover. The model predicts that teachers unions, by negotiating higher wages for teachers, lower the quit probability of high-ability teachers but raise the dismissal rate of underperforming teachers, as higher wages provide districts greater incentive to select better teachers. As a result, unions help the educational system reach an efficient equilibrium where high-quality teachers are matched with high wages. The unique district-teacher matched panel data for 2003-2012 enables me to use within-state and within-district variations, as well as instrumental variables, to identify union effects on teacher turnover. The data confirms that, compared to districts with weak unionism, districts with strong unionism dismiss more low-quality teachers and retain more high-quality teachers. The empirical analysis shows that this dynamic of teacher turnover in highly unionized districts raises average teacher quality and improves student achievement.

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1 Introduction

Recent studies suggest that teachers are the most important factor in improving the educational achievement of US students (Goldhaber, Brewer, and Anderson, 1999; Rivkin, Hanushek, and Kain, 2005; Burke and Sass, 2006). Yet, researchers find that the quality of the teaching workforce in the US has been decreasing for the past several decades (Murnane et al., 1991; Lakdawalla, 2001; Bacolod, 2003; Corcoran, Evans, and Schwab, 2004; Hoxby and Leigh, 2004). Raising teacher quality, therefore, becomes one of the primary objectives for policy makers in educational reforms. Staffing classrooms with high-quality teachers can be achieved by both hiring good teachers and retaining them in schools. Teacher turnover is a key factor that links both approaches.

The goal of this paper is to examine how teachers unions affect teacher turnover and ultimately influence teacher quality. This study examines two main types of teacher turnover that literature identifies: voluntary and involuntary job termination.[1] The former depends on teachers' decisions while the latter reflects school districts' assessments. Each type of turnover has a distinctive effect on the educational system, as teachers' objectives may differ from districts'. Therefore, a clear understanding of the dynamics of each turnover is critical for solving school staffing problems and raising teacher quality.

Many teachers transfer to other schools, and this is often referred to as "teacher migration." This type of voluntary job termination is generally considered a less significant form of teacher turnover, as it does not change the overall teacher supply. Thus, much empirical research has emphasized the other type of voluntary job termination in which teachers completely leave the teaching profession, referred to as "teacher attrition."

This study focuses on one of the determinants of teacher attrition − the role of teachers unions. A large number of studies examine the predictors of teacher attrition (Baugh and Stone, 1982; Murnane and Olson, 1990; Rees, 1991; Ingersoll, 2001; Imazeki, 2005; Hanushek, Kain, and Rivkin, 2004), and researchers find that teachers unions enhance teachers' well-being by raising pay and improving working conditions, potentially deterring teachers from leaving schools. Freeman (1980a) argues that, compared to non-union workers, union workers are less likely to quit their jobs mainly because they can take advantage of the collective "voice" effect in the unionized setting. Eberts (1987) shows that the probability of teacher attrition is lower in districts that have collective bargaining (CB) agreements. Rees (1991) finds a negative association between the strength of grievance procedures and teacher attrition. Building on this literature, my study investigates whether teachers unions raise teacher pay and whether the higher earnings encourage teachers to stay in their classrooms. Addi-

[1] Typically, involuntary job turnover includes layoff, dismissal, and mandatory retirement.

tionally, this study explores the link between teacher attrition and teacher quality on the premise that the self-selection pattern of quits can alter average teacher productivity.

Alternatively, school districts can dismiss less effective teachers based on teaching performance. According to the Teacher Follow-up Survey (TFS) for 2012-2013, only about 10 percent of former teachers left teaching involuntarily, validating why voluntary teacher turnover received more attention.[2] Most states have probationary periods lasting up to five years preceding tenure, and districts have the right to fire probationary teachers who do not meet their performance standards. States' statutes also specify a variety of causes for involuntary termination of tenured teachers, including incompetence in teaching.[3]

Critics claim that teachers unions overprotect the job security of ineffective teachers and that this practice is detrimental to educational outcomes. At first, this claim appears legitimate because teachers unions may seek to protect the job security of teachers, as any other workers associations will. However, the job security of public school teachers is addressed through the tenure system in most states, and tenured teachers are not easily dismissed, regardless of their union status. The economic intuition that is overlooked in teacher dismissal is that school districts have a strong motivation to dismiss low-quality teachers if they must pay the higher salaries that unions demand. Particularly, during the probationary period, districts will carefully evaluate new teachers' performances, as they must pay even higher wages once these teachers receive tenure. Therefore, it is essential to clarify whether unionized teachers can better secure their jobs than non-unionized teachers when their performance is below standard. This study makes the first attempt to rigorously test this assertion.

There are three big hurdles in examining issues regarding involuntary teacher turnover. The first is the lack of nationally representative data on teacher dismissal. For instance, Bridges (1986) and Theobald (1990) report dismissals due to poor performance in public schools, but the data are from a single state. The second is that, in many datasets, it is often unclear whether the dismissal decision is based on teachers' effectiveness or on certain shocks in the local labor market leading to school closings or layoffs. Ballou and Podgursky

[2]Additionally, even though the system allows job termination of underperforming teachers, this could be difficult to implement in practice. Districts may not want to leave students with substitute teachers whose productivity is unknown or they may try to avoid any risk of potential litigation from teachers.

[3]For instance, under current California state law, tenured teachers may be dismissed for dishonesty, unprofessional conduct, or unsatisfactory performance. Most tenured teachers must be evaluated at least once every two years. If, however, they receive an unsatisfactory evaluation, they must be assessed annually until they achieve a satisfactory evaluation or are dismissed. The dismissal process begins with a school district specifying reasons for dismissal and providing a 30-day notice of its intent to dismiss. If requested by the teachers, the process includes a formal administrative hearing and the right to appeal to a court. Before being dismissed for unsatisfactory performance, the school district must first provide employees a 90-day period to allow them an opportunity to improve their performance.

(1998) and Figlio and Kenny (2007) show that private schools are more likely than public schools to dismiss teachers, but the reason for dismissal was not specified. Lastly, most studies do not differentiate between the dismissal of non-tenured and tenured teachers who are covered by different employment contracts.

By documenting the extent of dismissal incidence due to poor performance in public schools for both non-tenured and tenured teachers and investigating the causal effect of teachers unions on the dismissal of teachers using nationally representative data, this study sheds light on teacher discharge that has been largely ignored in literature.

Due to the lack of comprehensive theoretical models that explain how unions behave or impact the educational system, the literature tends to focus on empirically estimating the effect of teachers unions on the education production function. This paper offers a theoretical framework on how teachers unions influence teacher turnover. Building on Hashimoto (1981) and Antel (1985), this study uses a simple job matching model with positive renegotiation costs (or transaction costs). The model has two periods in which the rent-sharing agreement between teachers and a school district is specified at the time of hire, based on their mutual expectations of teachers' productivity and their alternative job offers. Teachers in districts with strong teachers unions have high bargaining power, so they can negotiate for a greater share of the job matching rent. During the first period, a probationary period, teachers continue to browse alternative outside offers and the district learns the actual productivity of teachers. At the end of the first period, teachers decide to quit if their outside offer is greater than the first-period wage, and the district decides to dismiss them if their actual productivity is less than the expected productivity.

This model provides a unique contribution to literature by linking the strength of teachers unions to teacher staffing issues, as it makes three key predictions on voluntary and involuntary teacher turnover. First, unionism reduces teacher attrition by increasing salary, which makes the outside option less attractive. Second, in contrast to the commonly held belief that teachers unions overprotect the job security of teachers, the model predicts that unionism raises the dismissal of low-quality teachers during a probationary period because the high salary provides strong incentive to school districts to become more selective in hiring teachers. Lastly, through the impact on teacher turnover, unions assist the educational system in reaching an efficient equilibrium where high-quality teachers are matched with high wages.

For empirical analysis, I utilize three survey data by the National Center for Education Statistics (NCES): the School and Staffing Survey (SASS) for three waves (2003-2004, 2007-2008, and 2011-2012), its supplement Teacher Follow-up Survey (TFS) for each wave of the SASS, and the School Districts Finance Survey (SDFS). These datasets are large-scale and

nationally representative, offering a great deal of insight into the conditions of US education. By combining the SASS, the TFS, and the SDFS, I have created a unique district-teacher matched panel dataset, spanning about ten years following the enactment of the No Child Left Behind Act. This dataset provides an important link between teacher turnover and unionism, permitting me to conduct a comprehensive analysis of the union effects on teacher turnover and teacher quality in the US public school system. Moreover, this dataset allows me to control for various district-specific and teacher-specific demographics, by which my empirical analysis yields more accurate estimates of union effects on the educational system.

One of the major obstacles for empirical studies of union effects on the educational system is obtaining information on unionism. My data enable me to utilize diverse measurements of unionism to properly assess the strength of teachers unions. Han (2013) shows that the legal environment towards unionism is an important channel for unions to influence the well-being of teachers. Motivated by her findings, I measure the extent of unionism by four different aspects: the legality of collective bargaining, contractual status between districts and unions, union density in each district, and union membership status of teachers. This approach underlines the importance of a comprehensive view on the scope of union activities by integrating various metrics of unionism.

Another obstacle in union studies is the identification issue due to unobservable characteristics of school districts that are associated with both unionism and the educational system. Districts are more likely to have collective bargaining contracts if their legal environment towards unions is favorable. Moreover, more teachers join unions in districts with strong teachers unions than in districts with weak unions. If the unobservable characteristics of those districts are correlated with the educational system, the estimates of the union effects on educational outcomes will be biased.

I attempt to solve this identification problem by three methods. First, by taking advantage of multi-level characteristics of my dataset combining districts, schools, and teachers, I exploit the within-district variation of unionism to reduce omitted variable bias and selection bias using district fixed effects. Using the panel nature of the data, I also use the within-state variation of unionism. Second, I employ instrumental variables estimation to identify the effect of collective bargaining, using the difference in state laws towards collective bargaining and the size of union membership as instruments. Third, and most importantly, an unexpected legal change substantially restricting the collective bargaining of teachers in 2011 in four states forms a natural experiment, allowing me to use the difference-in-difference estimation to identify the causal effect of weakening unionism on teacher turnover. This natural experiment provides the final checking mechanism to examine if unionism has a causal impact on teacher turnover and teacher quality.

The empirical analysis confirms model predictions. The data show that the quit probability is 3 percent lower for teachers covered by bargaining contracts than for teachers with no agreement, and 1 percent lower for union teachers than for non-union teachers. Collective bargaining significantly raises the dismissal rate of non-tenured teachers. Union density also has a positive impact on the dismissal rate. As districts with strong unionism are able to retain more high-quality teachers and dismiss more low-quality teachers, the model ultimately predicts that the education quality will be higher in those districts than in districts with weak unionism. Consistent with this prediction, I find that teachers unions raise average teacher quality and improve student achievement.

Finally, the natural experiment occurred in four states provides strong evidence for the causal effect of unionism on teacher turnover. Since the new legal change decreases unionism, we expect to observe rising teacher attrition and declining teacher dismissal in those four states. The difference-in-difference estimation shows that the recent legal change reduces teacher quality, as it decreases teacher salary, diminishing districts' incentives to dismiss low-quality teachers and encouraging high-quality teachers to leave the teaching sector.

2 Model

Building on Antel (1985) and Hashimoto (1981), this paper focuses on young teachers who are just entering the labor force and have no prior experience, to control for unobserved factors such as employer-specific human capital accumulated during previous employment. These inexperienced, young teachers have similar credentials such as teaching certificates, college degrees, and other requirements. Thus, their ex-ante observable characteristics provide little information regarding true teacher productivity.

Suppose that both teachers and school districts are risk neutral.[4] The true teacher productivity is unknown to both parties prior to hire and is assumed to be match-specific so that each teacher has different sets of comparative advantage for different districts. Prior to hire, teachers and districts have mutually consented expectations, shaped from publicly available information about teachers' productivity on the current job and accessibility to outside offers. Both parties negotiate the employment contract, stipulating how the expected rent from matching will be shared between them over the full employment period.

[4]The risk neutrality assumption is not necessary for this model to work. For risk averse teachers who are less likely to move to other jobs to consider leaving teaching, their alternative job offer must be high enough to offset the risk premium, say ρ, that is positively associated with risk aversion. Risk averse districts that are concerned about realized teacher quality being lower than the expected level may impose higher performance standards (raise thresholds for dismissal by the risk premium) or have a longer probationary period proportional to their risk premium.

Assume that each teacher initially has a certain market value of general human capital H. Let m be a match rent, which can also be interpreted as an ex-ante expected teacher productivity, and α be the proportion of the match rent that teachers keep after the matching. Then, α measures teachers' negotiating power that depends on teachers' labor market conditions and legal setting towards teachers unions. For example, if teachers can collectively bargain in one district but not in another district, they will have a higher level of α in the former but lower level of α in the latter, ceteris paribus. If districts have bargaining contracts with unions, teachers in those districts will also have higher α than teachers in districts without such contracts. Thus, the legality of collective bargaining (CB) or the existence of bargaining contracts between teachers and their districts can be a proxy for α in each district. Suppose that, before CB is established, teachers make an independent decision to join unions at hire. Even when there exist no bargaining contracts (so α=0), teachers can unionize, and the strength of their collective voice can also bring higher earnings for union members.[5] Thus, in addition to their share of match rent specified in bargaining contracts, unionized teachers receive a wage premium associated with the strength of teachers unions. The function of the union wage premium can be derived as:

$$\beta = \beta(u),\ \beta \geq 0,\ \beta' > 0,\ and\ \beta'' > 0, \tag{1}$$

where u indicates union strength, which can be measured with union membership or the union density within the district, and β represents the union wage premium, assumed to be positively related to the magnitude of u at an increase rate in each district.[6] Then, the wage payment that teachers receive in each district is given by:[7]

$$w = H + \alpha m + \beta,\ 0 \leq \alpha \leq 1. \tag{2}$$

This expression implies that the variation of teachers' wages depends on the legal setting towards CB (α), as well as union membership status (u). Teachers earn higher wages if their contracts are covered by CB; moreover, they earn the union wage premium if union members. The school districts receive $(1-\alpha)$ share of the expected match rent m, and they need to pay for the union wage premium out of their share of match rent. The districts' gain

[5]Han (2013) and Freeman and Han (2013) find that union membership status and union density is associated with high teacher compensation in states that outlaw CB of public school teachers.

[6]We may consider β as a "net" union wage premium after paying union dues.

[7]It is noteworthy that in this model, u is not associated with either α or m. α is proxied by the legal and contractual environment for teachers unions, largely set before the matching, whereas u is determined by individual teachers who make an independent decision to be a union member in a given legal setting. For instance, two districts with the same union density may have the same β, but they may reach a different value of α if one district has a CB agreement while the other district has no such agreement.

is given by:

$$\pi = (1 - \alpha)m - \beta. \tag{3}$$

Prior to hire, both teachers and districts negotiate α and β in order to maximize the present value of their respective payoff derived from the match over the two periods of employment. During the first period, the learning process for both parties occurs; teachers continue to search and receive alternative job offers, and true teacher productivity is revealed through districts' monitoring. Suppose that only teachers know about their exact alternative offers, and only districts know about the true quality of their matching.[8] At the end of the first period, both parties make a simultaneous decision.[9] Teachers decide whether to stay or quit, and districts decide whether to dismiss or retain the teachers in the second period.[10]

Let the random variable ε indicate the value of the best alternative job's payoff that teachers receive during the first period, and the actual value of ε is revealed only to teachers at the end of the first period. If the new offer is greater than the current payoff of $\alpha m + \beta$, teachers quit. The underlying assumption is that high-quality teachers who are able to receive higher alternative offers during the first period are more likely to quit. The voluntary turnover, or quit probability, Q, is then given by:

$$Q = \int_{\alpha m+\beta}^{\infty} f(\varepsilon)\, d\varepsilon, \tag{4}$$

where $f(\varepsilon)$ describes the probability density function of ε.

Let the random variable η represent the difference between the revealed productivity during the first period and the expected productivity m with $E(\eta) = 0$. The actual value of η is revealed only to districts at the end of the first period. If teacher productivity is below expectation, the value of η is negative. If the magnitude of the negative η is large enough to entirely cancel out districts' payoff, districts dismiss the teacher permanently. The

[8]This double asymmetry of information implies that renegotiation during the first period becomes expensive as both parties have a motivation to lie about their findings, making this model more similar to Antel (1985) than to Hashimoto (1981). Teachers have an incentive to overstate their alternative offers, and districts to understate teacher productivity. Teachers expect that their districts are fair predictors (that districts believe there is an equal chance for teachers to outperform and underperform, relative to initial expectation), and districts maintain their initial expectation towards the value of teachers' alternative offers.

[9]Note that the length of probationary periods is not important in this model. The existence of a probationary period, not the length of it, determines the outcome. If districts have shorter probationary periods, the learning process happens quickly. In the preliminary analysis, I found no correlation between unionism and the length of probationary periods.

[10]Under the double asymmetry of information, the transaction cost becomes so high that renegotiation is infeasible once teachers are hired. The bargaining contracts usually last two to four years, so renegotiation is costly after both parties sign the contract. Thus, the value of α and β remain constant during employment.

involuntary turnover, or dismissal probability, D, is given by:

$$D = \int_{-\infty}^{-[(1-\alpha)m-\beta]} g(\eta)\ d\eta, \tag{5}$$

where $g(\eta)$ describes the probability density function of η. I assume that random variables ε and η are independent of H, α, m, β, and each other, so the learning process occurs separately for both teachers and districts during the probationary period.

Both teachers and school districts attempt to maximize their respective objective functions, the sum of the expected payoff during the probationary period and the present value of the expected payoff discounted at the rate of r during the second period. Only teachers who decide to stay and are not dismissed receive tenure and continue to keep their employment in the second period, so teachers attempt to maximize the following expected payoffs:

$$\begin{aligned}\pi_T = H + \alpha m + \beta + \frac{1}{r}\Big\{ & Q * E(\varepsilon|\varepsilon > \alpha m + \beta) \\ & + (1-Q) * [L * E(\varepsilon|\varepsilon \leq \alpha m + \beta) + (1-D) * (\alpha m + \beta)]\Big\}.\end{aligned} \tag{6}$$

School districts attempt to maximize their expected payoffs, as given by:

$$\begin{aligned}\pi_S = (1-\alpha)m - \beta + \frac{1}{r}\Big\{ & (1-Q) * (1-D) * \\ & \big\{[(1-\alpha)m - \beta] + E(\eta|\eta > -[(1-\alpha)m - \beta])\big\}\Big\}.\end{aligned} \tag{7}$$

Teachers earn higher wages if they negotiate a greater share (high α) of match rent and/or if the match rent (m) is higher. Intuitively, the greater the wage is, the lower the quit rate is. To the extent that teachers unions help teachers negotiate higher wages, unionism (u) will be negatively related to the quit rate. To investigate the effects of unionism on voluntary and involuntary job termination, I first consider the sign of the following comparative static derivatives regarding wages with respect to α, m, and u. From expression (2), and relying on the assumption of the positive relationship between u and β in expression (1), we get:

$$\frac{\partial w}{\partial u} > 0,\ \frac{\partial w}{\partial \alpha} > 0,\ \frac{\partial w}{\partial m} > 0. \tag{8}$$

The model predicts that teachers' wages will be positively associated with unionism, either through CB (α) and/or through union membership (u), and also with match rent (m). For the relationship between quits and wages, I use expressions (1) and (4) to derive

the following sign from the comparative static derivatives on quit probability:

$$\frac{\partial Q}{\partial u} < 0,\ \frac{\partial Q}{\partial \alpha} < 0,\ \frac{\partial Q}{\partial m} < 0. \tag{9}$$

According to the model, fewer teachers quit if their unions are strong (from α and u), once we control for H. Wages (from α and m) are also negatively associated with teacher attrition. The magnitude of the negative relationship between wages and quit rates depends on the size of the correlation between the wage, $H+\alpha m+\beta$, and the lower bound of the quit probability integral, $\alpha m + \beta$. Once controlling for H and conditioning on the independence between α and m, the correlation becomes one. However, the wage component $\alpha m + \beta$ is a good proxy for the lower bound of the quit probability integral, so assuming a constant β for all unionized teachers, the covariance of this correlation is:

$$\begin{aligned} Cov(\alpha m + \beta, \alpha m + \beta) &= Cov(\alpha m, \alpha m) = Var(\alpha m) \\ &= \sigma_\alpha^2 \sigma_m^2 \ + \ \mu_\alpha^2 \sigma_m^2 \ + \ \mu_m^2 \sigma_\alpha^2, \end{aligned} \tag{10}$$

where μ and σ^2 indicate the mean and the variance of the respective variables.[11]

The wage effects on dismissal decisions are somewhat complicated. Districts paying higher wages to teachers have a greater incentive to dismiss teachers with unsatisfactory performance. However, districts with better matching will be more tolerant towards underperforming teachers. From expressions (1) and (5), we have the following signs regarding the dismissal rate with respect to α, m, and u:

$$\frac{\partial D}{\partial u} > 0,\ \frac{\partial D}{\partial \alpha} > 0,\ \frac{\partial D}{\partial m} < 0. \tag{11}$$

According to expression (11), unionism (from α and u) is positively associated with teacher dismissal. Higher α and higher u yield higher wages, leaving less gains to districts, so districts paying higher wages will dismiss more teachers during a probationary period. Matching rent m, however, is inversely related to teacher dismissal. Higher matching rent leads to higher gains for districts, reducing dismissal incidence. Due to this opposite influence on dismissal, the total effect of the wage contract on dismissal is ambiguous.

After controlling for H, the effect of wages on teacher dismissal depends on the covariance between the wage component, $\alpha m + \beta$, and the upper bound of the dismissal probability integral, $-m + \alpha m + \beta$. Again, assuming β is a constant for unionized teachers and α and

[11] Assuming α and m are independent of each other, $Var(\alpha m) = E(\alpha^2 m^2) - [E(\alpha m)]^2 = E(\alpha^2)E(m^2) - [E(\alpha)]^2[E(m)]^2 = [(\sigma_\alpha^2 + \mu_\alpha^2)(\sigma_m^2 + \mu_m^2)] - \mu_\alpha^2 \mu_m^2 = \sigma_\alpha^2 \sigma_m^2 \ + \ \mu_\alpha^2 \sigma_m^2 \ + \ \mu_m^2 \sigma_\alpha^2$.

m are independent of each other, the covariance is:[12]

$$\begin{aligned} Cov(-m+\alpha m+\beta, \alpha m+\beta) &= Cov(-m+\alpha m, \alpha m) \\ &= Cov(\alpha m, \alpha m) - Cov(\alpha m, m) \\ &= Var(\alpha m) - Cov(\alpha m, m) \\ &= \sigma_\alpha^2\sigma_m^2 \ + \ \mu_\alpha^2\sigma_m^2 \ + \ \mu_m^2\sigma_\alpha^2 - \ \mu_\alpha\sigma_m^2. \end{aligned} \tag{12}$$

In this expression, the sign of the covariance is undetermined, but this covariance will be positive as long as the first three terms dominate the last term. If we compare the first and the last term in equation (12), the mean and the variance of teachers' bargaining power (α) determine the sign of the covariance. If the average bargaining power of teachers is low but more variant across school districts (small μ_α and large σ_α^2), the covariance between dismissals and wages is more likely to be positive. The current US legal environment for public school teachers displays this feature. In states that allow CB of teachers, some school districts sign bargaining contracts while others do not, leading to higher σ_α^2 and the positive sign of the covariance. In states that ban CB, both σ_α^2 and μ_α are zero, again resulting in the positive sign of the covariance.[13]

The implication of this model is that unions contribute to more efficient employment and pay structures in the educational system. As highly unionized districts, compared to less unionized districts, dismiss more low-quality teachers during probationary periods, D becomes smaller (approaching zero) for high-quality teachers but becomes greater (approaching one) for low-quality teachers in those districts. Q will decrease (approaching zero) for both types of teachers as they both receive higher wages during probationary periods in highly unionized districts. However, this becomes more binding for high-quality teachers because they will reduce Q more than low-quality teachers when wages rise. Thus, highly unionized districts will be able to retain more high-quality teachers than less unionized districts after probationary periods.

This selection mechanism influences the expected payoffs of both teachers and districts during the second period, since the quality of the teaching force will be greater. From expressions (6), (8), (9), and (11), we have the following relation between teacher quality,

[12]Assuming α and m are independent of each other, $Cov(\alpha m, m) = E(\alpha m^2) - E(\alpha m)E(m) = E(\alpha)E(m^2) - E(\alpha)[E(m)]^2 = E(\alpha)\{E(m^2) - [E(m)]^2\} = \mu_\alpha\sigma_m^2$.

[13]Another special case is if expected teacher productivity m is assumed to be the same across school districts ($\sigma_m^2 = 0$), simplifying this covariance to $\mu_m^2\sigma_\alpha^2$, whose sign is strictly positive. For instance, if a state, such as Hawaii, determines the bargaining status and wages for all districts, $\sigma_m^2 = 0$.

teachers' expected payoffs, and unionism:

$$\frac{\partial \pi_T^H}{\partial u} > \frac{\partial \pi_T^L}{\partial u}, \ \frac{\partial \pi_T^H}{\partial \alpha} > \frac{\partial \pi_T^L}{\partial \alpha} \tag{13}$$

where π_T^H and π_T^L represent the expected payoff of high-quality and low-quality teachers, respectively. This shows that in districts with strong unionism, the expected lifetime earnings in expression (6) is higher for high-quality teachers, as low-quality teachers are less likely to obtain tenure. Hence, high-quality teachers are better off in districts with strong unionism while low-quality teachers are better off in less unionized districts. This implies that, through unions' influence, high-quality teachers are matched with high wages and low-quality teachers are matched with low wages.

Districts are also better off when teachers unions are strong. During probationary periods, highly unionized districts pay higher salaries to all teachers (also to attract high-quality teachers), but once they learn the true productivity of their teachers, they offer tenure only to highly selected teachers. Thus, the expected lifetime payoff in expression (7) will be higher for districts with strong unionism.

Therefore, the ultimate prediction of this model is that the average teacher quality will be higher in districts with strong unionism, compared to districts with weak unionism. In other words, unions' influence on the educational system results in a superior equilibrium, matching high-quality teachers with high compensation.[14]

3 Data

The US Census Bureau collects the School and Staffing Survey (SASS) data for the National Center for Education Statistics (NCES) from a random sample of schools stratified by state and by school for elementary and secondary education. My study focuses on public elementary and secondary education schools. The SASS is composed of a series of questionnaires given to districts, schools, principals, and teachers in the selected schools. I obtain three waves of the SASS for the 2003-2004, 2007-2008, and 2011-2012 school years. For each wave, I combine information from the questionnaires directed to districts, schools, and teachers to form a multi-level dataset.

This multi-level dataset, in which teachers are grouped within their schools and schools are grouped within their corresponding districts, provides a way to construct a district-

[14]Temin (2002) presents the multiple equilibria of the teachers' market in the US using Akerlof's "Lemon" model. He also argues that the US is currently stuck at an inferior equilibrium, where lower salaries are matched with low-quality teachers, and cannot get out of it unless districts pay more to teachers.

teacher matched dataset. The district-teacher matched dataset not only offers significant insights into the general condition of US public education but also provides an important link in examining the impact of teacher turnover on the educational system, by utilizing various perspectives of different agents in the educational sector. To compensate for over-sampling and under-sampling of the stratified survey design, and to obtain unbiased estimates of the national population of schools and teachers, each observation is weighted by the inverse of its probability of selection during the survey year. I then merge three waves of district-teacher matched datasets to construct panel data that allows me to follow the same school districts for three consecutive survey years covering 2003-2012.

One year after the SASS survey is collected, the Census Bureau contacts the same schools again and gives the second questionnaire to all teachers in the original sample to obtain further information about the status of these teachers. This information constitutes the Teacher Follow-up Survey (TFS) data. The Census Bureau collects a separate survey for teachers who left the teaching sector, and this comprises the TFS for Former Teachers. The self-report data from te TFS for former teachers are useful because the data are from teachers who actually left teaching, rather than from current teachers who have doubts about their careers. I combine the 2011-2012 SASS with the 2012-2013 TFS to construct the 2011-2013 SASS-TFS dataset, which is the most recent data to date. I also construct the 2007-2009 SASS-TFS dataset by combining the 2007-2008 SASS with the 2008-2009 TFS to investigate the sensitivity of the results from 2011-2013 SASS-TFS dataset.

This study also makes use of the School Districts Finance Survey (SDFS) from the Education Finance Statistics Center (EDFIN) of NCES, which has detailed annual fiscal data on public elementary and secondary education for every school district in the US. I merge information from the SDFS with the SASS so that all my datasets include districts' finance information, allowing me to examine the union effects among districts with similar financial status, measured with the log of districts' total revenue, which was impossible to do in other studies.

Additionally, I include information of the Comparable Wage Index (CWI), developed by Taylor and Fowler (2006), which measures the salaries of occupations that are comparable to teaching in the local labor market using the baseline estimates from the 2000 US Census and annual data from the Bureau of Labor Statistics' Occupational Employment Survey. The CWI is available at the district level, so it provides for geographically appropriate comparisons for locality differences in cost of living and other economic conditions of the local labor market in the mid-2000s.

To estimate the union effects on educational outcomes, I look at teacher quality and student achievement. For teacher quality within each district, I use the variable indicating

whether a teacher is recognized as a Highly Qualified Teacher (HQT).[15] Although the HQT lacks an explicit link to the actual educational performance of their matched students, it can serve as a proxy for teacher quality, as it helps identify more qualified teachers. To measure the student achievement, I bring in publically available data on high school dropout rates by school district provided by NCES and combine with the SASS data.

Table 1 provides summary statistics of key variables from the 2011-2013 SASS-TFS. The data comprise about 4,600 districts, a third of US public school districts, and approximately 37,200 teachers are nested within these 7,500 schools. More than 50 percent of teachers have a masters' degree or higher degree. On average, approximately 70 percent of public school teachers are unionized. Over 75 percent of teachers are certified as HQT. The 2012-2013 TFS for former teachers contains a sample of about 1,600 teachers, telling us that about 4 percent of public school teachers have left teaching (both voluntarily and involuntarily) between the 2011-2012 and the 2012-2013 school year. About 88 percent of former teachers (1,380 teachers) left teaching voluntarily, and about half of this voluntary termination is attributed to retirement. Six percent of public schools are charter schools. The overwhelming majority of teachers are white whereas more than 30 percent of student bodies are minority. About half of students are approved for free or reduced-price lunches. About 56 percent of public school districts have collective bargaining (CB) contracts with their teachers, and over 30 percent of districts have no agreement. The average student-teacher ratio of districts is 15. On average, each district hires 27 new teachers, and about two teachers per district are dismissed for poor performance.[16]

4 Measures of Unionism

The legal environment for teachers unions varies greatly by state. Following Moe (2011), I classify states into four groups along two dimensions: the legality of collective bargaining of public school teachers and the existence of agency shop.[17] Agency shop is a union security agreement stipulating that non-union employees must pay union dues, as their wage contracts

[15]The HQT requirement is a provision under No Child Left Behind (NCLB). Generally, to be a Highly Qualified Teacher (HQT), a teacher must meet the states' requirements: 1) have a bachelors' degree; 2) hold full state certification or licensure, including alternative certification; and 3) demonstrate competency in the subject area they teach, such as passing a subject area test administered by the state.

[16]One source of measurement error in teacher dismissal in the SASS occurs when districts recommend voluntary resignation to teachers who fail to meet teaching standards, rather than dismissing them for poor performance. These teachers may identify their status as a voluntary quit, rather than as a dismissal. I have no data on the prevalence of this practice.

[17]The source for this categorization is: "Teacher Monopoly, Bargaining, and Compulsory Unionism, and Deduction Revocation Table" by National Right to Work Foundation (2010), American Federation of State, County and Municipal Employees (AFSCME).

Table 1: Descriptive Statistics
District-teacher Matched SASS data, 2011-2012

	N	Mean	SD	Min	Max
Public School Teachers					
Male	37,230	0.313	0.464	0	1
Master's degree and above	37,230	0.543	0.498	0	1
Experience	37,230	13.46	9.813	1	54
Secondary school teacher	37,230	0.746	0.435	0	1
Full time	37,230	0.922	0.268	0	1
Union member	37,230	0.710	0.454	0	1
Hispanic	37,230	0.051	0.22	0	1
Black	37,230	0.053	0.225	0	1
Asian	37,230	0.017	0.13	0	1
Other	37,230	0.019	0.136	0	1
HQT	37,230	0.788	0.409	0	1
Alternative certification	37,230	0.144	0.351	0	1
Voluntary quit*	1,560	0.884	0.32	0	1
Quit due to retirement*	1,380	0.477	0.499	0	1
Public Schools					
Charter school	7,480	0.062	0.24	0	1
Hispanic students	7,480	0.151	0.221	0	1
Black students	7,480	0.137	0.224	0	1
Asian students	7,480	0.028	0.06	0	0.823
Indian students	7,480	0.027	0.112	0	1
Pacific students	7,480	0.004	0.029	0	1
Multiracial students	7,480	0.017	0.039	0	1
Hispanic teachers	7,480	0.044	0.12	0	1
Black teachers	7,480	0.061	0.149	0	1
Asian teachers	7,480	0.009	0.034	0	0.913
Indian teachers	7,480	0.006	0.039	0	0.9
Pacific teachers	7,480	0.003	0.030	0	1
Multiracial teachers	7,480	0.004	0.022	0	0.529
School days	7,480	178.7	10.75	30	365
ESL fraction	5,300	0.079	0.13	0	1
Eligible for free/reduced-price lunch	7,160	0.475	0.282	0	1
Districts					
Collective bargaining (CB)	4,590	0.576	0.496	0	1
Meet and confer (MC)	4,590	0.109	0.311	0	1
No agreement (NA)	4,590	0.315	0.465	0	1
Contract days	4,590	186.6	11.58	140	365
Pupil-teacher ratio	4,590	14.71	17.81	0.163	1,113
Newly hired teachers	4,590	27.29	66.87	0	1,901
Total dismissed teachers	4,590	2.14	8.80	0	207
Salary of teachers with BA and 0 exp. ($)	4,380	36,025	5,758	14,997	63,500
Salary of teachers with MA and 0 exp. ($)	4,380	39,418	6,349	15,359	68,500
Salary of teachers with BA and 10 yr. exp. ($)	4,380	45,657	9,234	19,040	83,021
Salary of teachers with MA and 10 yr. exp. ($)	4,380	50,785	10,481	21,181	94,844
District revenue (in millions $)	4,460	77.79	352.1	0.051	21,024
CWI	4,370	1.151	0.157	0.833	1.669

*Source: The TFS (Teacher Follow-up Survey) 2012-2013 for former teachers.

are covered by collective bargaining regardless of their union status. The first group, which I call the "High-CB" group, is composed of 23 states that have a compulsory collective bargaining law ("duty-to-bargain") mandating districts to bargain with a representative union in good faith when the union asks for it. This group allows mandatory agency fees for non-union members.[18] The second group, the "Med-CB" group, also has a compulsory bargaining law but prohibits mandatory agency fees. There are 11 states in this group, and they are located in the Midwest and South.[19] The third group, the "Low-CB" group, allows local school districts to sign collective bargaining agreements but bargaining is not mandatory, and nine states fit into this group.[20] The last group, the "No-CB" group, bans the collective bargaining of teachers, and there are seven states in this group.[21] All states except Arizona are located in the South.

In 2010-2011, state legislators in Indiana, Idaho, Tennessee, and Wisconsin launched unprecedented initiatives substantially restricting the collective bargaining rights of public employees, including making collective bargaining non-mandatory and eliminating the ability to collect union dues through payroll deductions.[22] These four states currently belong to the Low-CB group under my categorizations, as they no longer have mandatory collective bargaining laws.[23] This sudden change in the legal environment towards unionism forms a natural experiment, allowing me to investigate the impact of weakening unionism on teacher turnover in those four states.

The legality of CB does not guarantee bargaining contracts between teachers and their districts. Even the districts that are under mandatory CB laws can fail to reach an agreement for bargaining contracts. For those districts and districts that outlaw CB, meet and confer (MC) can be an alternative to CB.[24] In this study, I refer to both the legality of CB and the

[18]These states are Alaska, California, Connecticut, Delaware, Hawaii, Illinois, Maine, Maryland, Massachusetts, Michigan, Minnesota, Montana, New Hampshire, New Jersey, New Mexico, New York, Ohio, Oregon, Pennsylvania, Rhode Island, Vermont, Washington, and Wisconsin.

[19]These states are Florida, Idaho, Indiana, Iowa, Kansas, Nebraska, Nevada, North Dakota, Oklahoma, South Dakota, and Tennessee.

[20]These states are Alabama, Arkansas, Colorado, Kentucky, Louisiana, Missouri, Utah, West Virginia, and Wyoming.

[21]These states are Arizona, Georgia, Mississippi, North Carolina, South Carolina, Texas, and Virginia.

[22]In Idaho, collective bargaining is not allowed if the union is unable to prove that at least half the districts' teachers are union members. The new law also limits collective bargaining to teacher salaries and benefits. In Indiana, collective bargaining is no longer mandatory, and only wage and wage-related items of teachers can be bargained. Tennessee also passed a similar law making collective bargaining non-mandatory. Wisconsin's new law eliminates the agency shop and restricts collective bargaining so that only wage and wage-related items can be bargained. It also requires teachers unions to have annual recertification.

[23]Several other states also passed laws weakening the union activities of public sector employees. These states include Michigan, Nebraska, New Hampshire, New Jersey, and Oklahoma. The terms of the legal changes in these five states, however, are more subtle compared to changes ID, IN, TN, and WI. Thus, the five states remain in the same group categories. See Freeman and Han (2015) for further discussion.

[24]During meet and confer (MC), unions and management exchange views and discuss proposals which

Table 2: Summary Statistics by Legal Environment
District-teacher Matched SASS-TFS data, 2011-2013

	High-CB group	Med-CB group	Low-CB group	No-CB group
Total Enrollment (K-12)	5,110	6,490	5,780	10,270
	(22,500)	(13,190)	(9,900)	(18,430)
Pupil-teacher ratio	15.19	14.25	14.34	14.63
	(4.05)	(3.01)	(2.83)	(2.76)
Collective bargain (CB)	0.864	0.796	0.275	0.001
	(0.344)	(0.404)	(0.446)	(0.002)
Meet and confer (MC)	0.066	0.117	0.182	0.11
	(0.47)	(0.316)	(0.385)	(0.299)
No agreement (NA)	0.059	0.087	0.543	0.89
	(0.235)	(0.277)	(0.499)	(0.314)
Union density	0.925	0.61	0.602	0.486
	(0.263)	(0.487)	(0.482)	(0.499)
Salary for BA and no exp	38,350	33,770	35,450	35,770
	(6,183)	(3,251)	(4,286)	(5,062)
Salary for BA and 10 exp	51,010	40,080	42,830	41,730
	(9,556)	(4,654)	(5,111)	(4,789)
Salary for MA and no exp	42,280	36,740	39,010	38,440
	(6,701)	(3,847)	(4,867)	(4,983)
Salary for MA and 10 exp	57,780	44,960	47,460	45,270
	(10,360)	(5,558)	(5,875)	(5,121)
Base salary/contract days	302.5	229.2	240.6	228.3
	(113.4)	(62.96)	(82.81)	(57.16)
Alternative certification	0.103	0.118	0.141	0.253
	(0.304)	(0.323)	(0.347)	(0.435)
Newly hired teachers /	6.10	8.07	8.05	8.60
all teachers (in hundreds)	(4.84)	(4.74)	(5.04)	(5.54)
Quit probability for	0.012	0.022	0.021	0.037
non-retirement reasons	(0.11)	(0.15)	(0.14)	(0.188)
Total dismissed teachers /	1.41	1.22	1.36	1.07
all teachers (in hundreds)	(1.77)	(1.60)	(1.36)	(1.36)
High school dropout rates	10.99	6.65	15.40	15.36
	(11.40)	(6.06)	(23.14)	(18.17)

Note: Standard deviations are reported in parentheses. The source for high school dropout rates is Local Education Agency (School District) Universe Survey Dropout and Completion Data by NCES Common Core of Data (CCD).

can lead to an agreement that is likely to affect outcomes, but this agreement is legally unenforceable. In states that prohibit public sector bargaining, MC is the only agreement option available to employers and employees. In some cases, both districts and teachers mutually understand the MC agreement as implicitly binding, just like CB contracts. For example, in Arizona, where CB is not permitted, about half of districts have MC agreements with teachers, and all teachers, including those who opt out of MC, are covered by the same MC agreements.

actual bargaining contract together as a "legal setting."

Table 2 reports key statistics from the 2011-2013 SASS-TFS by group sharing the same legal standing towards teachers unions. The majority of districts in the High-CB and Med-CB group are covered by CB, but the majority of districts have no agreement with teachers in the Low-CB and No-CB groups. MC is most common in the Low-CB group. Union density is highest in the High-CB group and lowest in the No-CB group. The union density in the Med-CB group is similar to that of the Low-CB group, even though the Med-CB group has a compulsory bargaining law but the Low-CB does not. This suggests that agency fee plays an important role for unions to sustain membership. The average salary schedules in all categories are highest in the High-CB group. The fraction of teachers who enter teaching through an alternative certification program is lowest in the High-CB group and highest in the No-CB group.

The pattern of employment and teacher turnover differs by group. The proportion of newly hired teachers in the teacher force is slightly lower in the High-CB group than in other groups, as the average K-12 enrollment size is smaller in the High-CB group. Teachers' quit probabilities for non-retirement reasons are lowest in the High-CB group and highest in the No-CB group. The fraction of teachers dismissed due to poor performance is highest in the High-CB group and lowest in the No-CB group. Average dropout rates are lowest in the High-CB group but highest in the No-CB group.

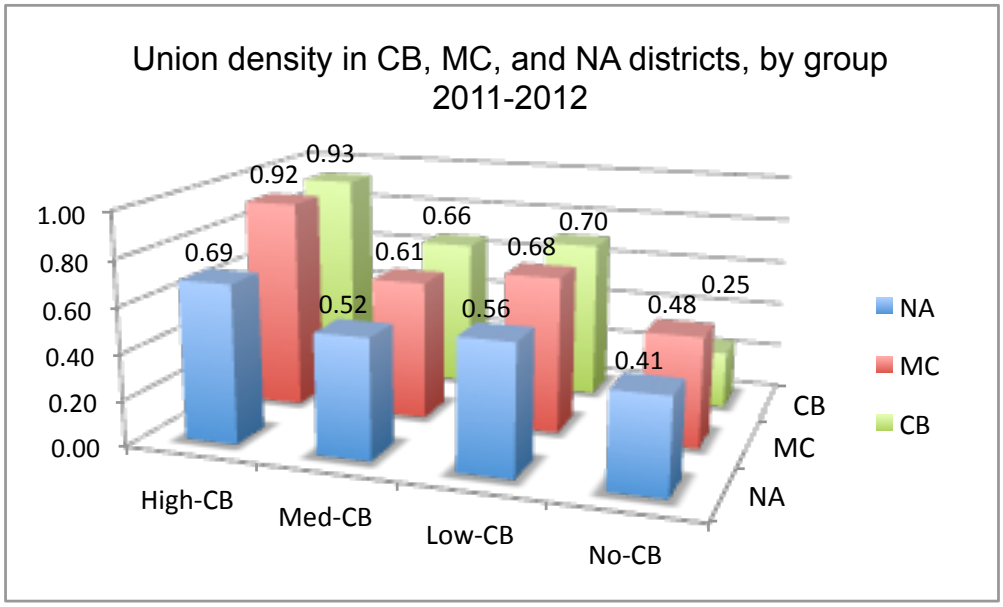
The most interesting finding in Table 2 is that about half of teachers still join unions, even in the No-CB group where bargaining is not allowed. Regardless of states' legal environments towards CB, teachers unions can engage in political activities, such as lobbying school districts for better compensation schemes and electing members of school boards that are positively inclined to unions' requests. Therefore, the union density of districts is another mechanism through which unions affect the educational system in the absence of CB.

Figure 1 describes the relation between legal environments towards unions and union density by contractual status. Intuitively, we expect to see greater union membership status in states with a more favorable legal environment towards unionism and in districts with CB contracts. In the High-CB group, the average union density of districts covered by CB or MC is above 90 percent. The density of districts with no agreement is 70 percent − 20 percentage points lower than that of districts with CB or MC but still quite high. The pattern of union density is similar for the Med-CB and Low-CB groups, as density is highest in CB districts and lowest in NA districts for both groups. However, the average density for all cells is slightly higher for the Low-CB group than for the Med-CB group. The average union density is lowest for no-agreement districts in the No-CB group, where CB is prohibited. However, more than 40 percent of teachers are union members in districts

with no agreement, and half of teachers join unions in MC districts. Two districts in the No-CB group indicate that they have CB agreements, and their average union density is 25 percent.[25]

Figure 1 suggests that the legal environment towards CB does not capture the true strength of unionism, particularly for states in the Low-CB and No-CB groups, where a substantial number of teachers join unions but CB is rarely or never used. It also suggests that studies using the existence of CB or duty-to-bargain law as a sole measure of unionism will fail to properly measure the variation of unionism in the Low-CB or No-CB groups. Union density is a better metric to measure the strength of unions in those groups. In the High-CB group, however, over 90 percent of teachers are unionized and more than 85 percent of school districts have bargaining contracts. My calculation based on the SASS panel data reveals that about 70 percent of districts without any agreement manage to reach either bargaining contracts or MC agreements by the next survey year. Thus, the spillover and threat effects of unionism may be strong in the High-CB group. Studies focusing on the High-CB states, therefore, face more difficulty in measuring union effects.[26]

Figure 1: Relation between Union Density and Legal Settings



Source: District-teacher Matched SASS data, 2011-2012

[25] Although these districts report that they have CB, these contracts shall be considered as MC agreements. According to Texas statue Sec. 617.002, a CB contract with a labor organization regarding wages, hours, or conditions of employment of public employees is void.

[26] The spillover or crowding effect occurs when higher wages in the unionized sector of the labor market result in unemployment, and displaced workers "spill over" into the non-union sector and depress non-union wages. Some studies use union density as a measure of spillover of CB when estimating union effects on

This study conducts a comprehensive analysis of union effects by fully utilizing measures of unionism available in the data. The multi-level and cross-sectional nature of my data permits me to consider various aspects of unionism and utilize four different measures of it: legality of CB, contractual status between teachers and districts, union membership status of individual teachers, and union density within each district (which I compute using the union membership information of teachers). If the data is at the teacher level, I utilize all four measures of unionism. If the data is at the district level, the union membership measure is unavailable. I use these measures together to minimize measurement errors in assessing the strength of unions in diverse legal environments. Moreover, the use of panel data enables me to exploit the variation of unionism, through either changes in contractual status or changes in union density over time.

5 Empirical Strategy

Expression (8) predicts that the legal environment (whether or not CB is legal) and contractual status (whether or not there is any legally binding contract between districts and teachers unions), both of which can serve as a proxy for the market power of teachers unions (α), are positively linked to teacher pay. The strength of unionism (u) is also predicted to have a positive association with teacher pay. I test these hypotheses using the SASS panel data by estimating the following equation:

$$W_{kst} = \beta_0 + \beta_1 Union_{kst} + \beta_2 X_{kst} + \delta_s + \lambda_t + \epsilon_{kst}, \tag{14}$$

where k, s, and t indicate districts, states, and years, respectively. W represents teacher salary, and $Union$ measures the unionism of districts. δ_s is the state fixed effects and λ_t is the year fixed effects. X is a vector of the characteristics of districts, and ϵ is the error term representing the unobservable characteristics of district k of state s in year t.

To test if unionism affects teacher dismissal, I estimate equation (13) with the dependent variable of the dismissal rate (D), measured by the number of teachers dismissed for poor performance divided by the number of all teachers in hundreds, instead of wages. I examine the effect of unionism on the dismissal rate for both non-tenured and tenured teachers.

The information for teacher quits is collected from former teachers surveyed in 2012-2013.

teacher pay (Delaney, 1985; Zwerling and Thomason, 1995). Threat effects occur when non-union employers respond to the threat of unionization by increasing the earnings and benefits of their workers. The evidence on threat effects is mixed. (Dickens and Katz, 1987a; Krueger and Summers, 1988; Neumark and Wachter, 1992 and 1995; Babcock, Engberg and Greenbaum, 2005; Farber, 2005; Millimet and Rangaprasad, 2007; Winter, 2011). When the vast majority of districts are covered by CB, both spillover effects and threat effects may be greater.

I estimate the following equation using the cross-sectional 2011-2013 SASS-TFS data to test if unionism reduces teacher attrition:

$$Q_{ijks} = \beta_0 + \beta_1 Union_{ijks} + \beta_2 X_{ijks} + \gamma_k + \epsilon_{ijks}, \tag{15}$$

where i, j, k, and s indicate teachers, schools, districts, and states, respectively. Q represents the binary indicator for voluntary quits for teachers: Q=1 if teachers who were in the classroom during the 2011-2012 school year left the teaching sector in the 2012-2013 school year for reasons other than retirement, and Q=0 if teachers still remain teaching in 2012-2013. X is a vector of control variables for teachers,[27] and γ_k is district fixed effects. Depending on the level of observation (whether the data is at the teacher level or at the district level) and model specification, I use a different combination of measures of unionism.

To investigate the effect of teacher turnover on teacher quality, I estimate equation (14) using HQT, instead of quit rate, as a dependent variable, utilizing the teacher-level SASS data. For union effects on high school dropout rates, equation (13) with the dropout rate as a dependent variable is estimated using the district-level SASS data. To match the time frame with the analysis on teacher attrition, I focus on the 2011-2013 SASS data.

Regressions for teachers' salary schedules, dismissals, and dropout rates are weighted by districts' final sample weight because those dependent variables are contained in the district-level data. For quit probability and HQT, I use teachers' final sample weight, as they are included in the teacher-level data. All standard errors are clustered either within districts or states, to allow for correlation within districts or states, depending on whether the main data is at the teacher level or at the district level.

State fixed effects models can eliminate omitted variable bias caused by cultural attitudes towards unionism within each state (for instance, pro-union or anti-union), as they tend to be constant over time. However, state fixed effects models leave only little variation in CB in many states, resulting in imprecise estimation, because some states ban CB while some states have over 95 percent bargaining coverage.[28] District fixed effects also have a limitation. The

[27]Control variables include attributes of districts, schools, and teachers. District-level control variables include log (CWI), log (districts' total revenue), log (total student enrollment grades K-12), log (number of days in the school year), students' ethnicity and race, teachers' ethnicity and race, urban regions, and census locations. School-level control variables include school levels and fraction of students eligible for free/reduced-price lunch programs. Teacher-level control variables include gender, experience, interaction between experience and gender, education level, ethnicity, race, full-time indicator, and secondary schools teacher indicator.

[28]State fixed effects models for the effect of contractual status only capture the variation in contractual status from districts that change contractual status over time. However, even if there is no bargaining contract for a current period after the old bargaining contract is expired, unions and districts continue to negotiate a new contract. During the negotiation period, current salaries are more likely to reflect terms from the expired contract, making the estimation on effect of contractual status less reliable. Moreover, in some

spill-over effect of CB within a district may reduce the effect of union membership, especially for the High-CB group where all teachers are covered by the same contract, regardless of their union membership status. Thus, rather than using the fixed effects approach, I employ the instrumental variables estimation when CB is used to measure unionism.

I utilize four instruments for CB. The first three instruments are state laws specifying the legality of CB, obligation for CB, and agency shop. The idea is that states' different attitudes towards unionism shape a distinctive legal environment for union activity, and districts covered by any of these laws are more likely to establish bargaining contracts with unions.[29] As long as CB is allowed, unions can persuade districts to sign bargaining contracts when a majority of teachers support their unions. Hence, I also use the majority rule of union membership of districts (whether the union density is greater than 50 percent) as an additional instrument for CB. The instruments of state laws also capture states' attitudes towards unionism, which can potentially affect the educational system. These instruments, therefore, are very likely to satisfy the exclusion restriction, as they will affect outcome variables only through CB. I use a combination of these instruments, depending on the dependent variable of the models, and test the exogeneity condition in each model.

Occurring in Indiana, Idaho, Tennessee, and Wisconsin, all of which have compulsory CB laws, the natural experiment in 2010-2011 allows Freeman and Han (2015) to estimate the causal effect of the legal changes restricting the scope of the bargaining rights of teachers on CB coverage. Using the difference-in-difference estimation, with the treatment group composed of the four states and the control group including all other states that also mandate CB, they find that the new regulations dramatically weaken teachers' unionism. The legal change in the four states reduced the bargaining coverage of public school teachers by 24 percent and union density by 11 percent. Building on their study, I investigate the effects of the legal changes in the four states on teacher turnover. We should expect that the declining unionism would lower teacher salaries, which then raises teacher attrition and reduces teacher dismissal. To test these hypotheses, I use the difference-in-difference estimation of the following equation:

$$Y_{kst} = \alpha_0 + \alpha_1 Treat_{kst} + \alpha_2 After_{kst} + \alpha_3 (Treat_{kst} * After_{kst}) + \epsilon_{kst}, \tag{16}$$

where k, s, and t indicate districts, states, and years, respectively. $Treat$ equals to 1 for the treatment group and 0 for the control group, and $After$ equals to 1 if the year is 2011-2012

states such as Hawaii, the state government runs all public schools, resulting in no variation in contractual status across districts.

[29]These laws serve as instruments for CB, but not for union membership (or union density). Union membership is buttressed by freedom of association as mandated by the Constitution, regardless of the lawfulness of CB.

and 0 if the year is before 2011. α_3 gives us the difference-in-difference estimator for the effect of legal changes on outcomes.

6 Results

6.1 The Effect of Teachers Unions on Teacher Salaries

To the extent that the legality of CB or the existence of bargaining contracts measures teachers' market power for wage negotiation, we expect these legal settings to have a positive association with teacher pay. Table 3 presents the estimates of regressions of log of teacher salary on states' legal environments towards CB. Dependent variables in columns (1) through (4) are districts' salary schedules for teachers with a bachelor's degree and no experience ("BA+0 exp"), a master's degree and no experience ("MA+0 exp"), a bachelor's degree and ten years of experience ("BA+10 exp"), and a master's degree and ten years of experience ("MA+10 exp"), respectively. The reference group is the No-CB group, which bans the CB of teachers. Column (1) shows that, compared to the No-CB group, the other groups allowing CB pay their entry-level teachers 5-10 percent more. Column (2) shows that novice teachers with master's degrees in these three groups earn higher wages than those in the No-CB group by 7-13 percent. The High-CB group pays teachers the most, as expected, since it has the highest bargaining coverage and union density. The Med-CB group, however, is not the second highest paying group.[30] Columns (3) and (4) show that, compared to other groups, only the High-CB group pays the wage premium of 15-18 percent to teachers with 10 years of experience. Overall, districts that allow CB pay a statistically significant wage premium for teachers, and the wage premium is greater for more experienced teachers than for those less experienced. This result is consistent with Winters (2011) who find that the union effect on teachers' starting salary is much smaller than union effect on salaries of experienced teachers. Each group is the assembly of states, so state fixed effects models are not employed.

Table 3 also shows other determinants of teacher pay. School districts with a high fraction of minority students pay their teachers more. Teachers in large districts (measured by student enrollment size) or in disadvantaged districts (indicated by a higher proportion of students eligible for free/reduced-price lunch programs) are paid significantly less. Coefficients for the log of CWI and districts' revenue are significantly positive, suggesting that districts with

[30]Han (2013), who also finds this pattern, argues that the Med-CB group may have problems with "free riders." When non-union teachers are not obliged to pay union dues even if they are covered by the same contracts with union members, the financial status of unions should weaken, diminishing the bargaining power of unions.

Table 3: Estimates of the Effect of Legal Environment towards Collective Bargaining on Teacher Salary Schedule, 2003-2012

Dependent Variable: Log(salary schedule of districts)

VARIABLES	(1) BA+0 exp	(2) MA+0 exp	(3) BA+10 exp	(4) MA+10 exp
High-CB	0.100***	0.126***	0.155***	0.183***
	(0.027)	(0.029)	(0.037)	(0.040)
Med-CB	0.053***	0.068***	0.008	0.039
	(0.017)	(0.024)	(0.027)	(0.030)
Low-CB	0.055***	0.087***	0.008	0.035
	(0.018)	(0.026)	(0.028)	(0.033)
% Hispanic students	0.134***	0.113***	0.103***	0.079**
	(0.021)	(0.022)	(0.033)	(0.037)
% Black students	0.045**	0.062***	0.023	0.040
	(0.019)	(0.021)	(0.023)	(0.027)
% Asian students	0.307***	0.287***	0.275***	0.252***
	(0.050)	(0.078)	(0.066)	(0.074)
% Other students	0.078**	0.082**	0.027	0.038
	(0.031)	(0.034)	(0.039)	(0.044)
Log(enrollment)	-0.030***	-0.031***	-0.036***	-0.038***
	(0.006)	(0.009)	(0.009)	(0.011)
Free lunch	-0.054***	-0.062***	-0.050*	-0.063**
	(0.017)	(0.020)	(0.028)	(0.031)
Log(CWI)	0.353***	0.375***	0.349***	0.389***
	(0.057)	(0.058)	(0.073)	(0.081)
Log(school days)	0.213	0.283*	0.355**	0.449***
	(0.179)	(0.159)	(0.166)	(0.145)
Log(revenue)	0.059***	0.061***	0.070***	0.077***
	(0.007)	(0.009)	(0.010)	(0.012)
Year FE	YES	YES	YES	YES
Observations	11,700	11,670	11,600	11,650
Adjusted R^2	0.689	0.672	0.677	0.687

Note: Errors are clustered within states (presented in parentheses). $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$. The data source is the district-teacher matched 2003-2012 SASS panel data. Other covariates include teachers' race and ethnicity in percent, census regions and urbanism of the districts that schools are located in. The number of observations is different for each OLS model because the information on the particular salary schedule is not available for some districts.

higher living costs or a better financial situation, respectively, tend to pay their teachers more. Teachers are also compensated more for longer school days.

The results in Table 3 are consistent with the model prediction that the legality of CB has a positive relationship with teacher pay. The magnitude of the association between unionism

and teacher pay greatly varies across these groups, indicating that union effects in a certain legal environment cannot be generalized to other legal environments. Although union laws can set a favorable atmosphere for unionism, they do not ensure that districts and teachers will sign bargaining contracts.

Table 4 examines the effect of the actual contractual status of districts on teacher salaries. Columns (1) through (4) present the estimated coefficients of the effect of CB and MC on teacher salary schedules. In this analysis, the reference group is districts that have no agreement with unions. In column (1), the effect of contractual status on the BA+0 exp is insignificantly different from zero. Column (2) shows that districts covered by CB pay their novice teachers with master's degrees significantly more, by 5 percent, compared to no-agreement districts. In columns (3) and (4), salaries for teachers with ten years of experience are 8-12 percent higher in bargaining districts relative to no-agreement districts. Districts with MC agreements, although legally unenforceable, also pay higher salaries to their teachers, and the wage premium is higher for experienced teachers. This result shows that unions indeed support a seniority-based pay system through bargaining contracts.

To avoid imprecise estimation in the state fixed effects models, I use the instrumental variables estimation, and columns (5) through (8) of Table 4 present the results.[31] The instruments for CB are the mandate of CB and union density greater than 50 percent. The first stage F-statistic and Hansen's J-statistic for the over-identification test are reported at the bottom of Table 4. These statistics show that the instruments are highly relevant and exogenous in all IV regression models. The IV estimations show that the effects of CB on all salary schedules are statistically significant at the 1 percent level. Compared to no-agreement districts, districts covered by CB pay 6-8 percent higher salaries to entry-level teachers and 13-17 percent more to experienced teachers. MC also shows greater and more significant effects on teacher salaries than in OLS models. The results in Tables 3 and 4 are, therefore, consistent with the model prediction that legal support for the bargaining power of teachers unions raises teacher pay.

The fact that the IV estimate is twice as large as the OLS estimate suggests that the OLS estimate suffers from omitted variable bias (for example, districts with negative attitudes towards unionism sign bargaining contracts with little increase in wages). Another reason for large IV estimates is that the IV estimator tends to measure local average treatment effects (LATE) rather than average treatment effects (ATE).[32]

[31] In the High-CB and No-CB groups, there is little variation in contractual status that state fixed effects models can exploit. Adding state fixed effects to models in Table 3 and models (1) through (4) in Table 4, in fact, reduces the magnitude of coefficients and eliminates the significance of the contractual status.

[32] For instance, with the legality of CB as an instrument for CB, the IV estimation will measure the effects of CB on teacher salary if the law prohibiting bargaining of teachers were abolished. The legality of CB

Table 4: Estimates of the Effect of Contractual Status on Teacher Salary Schedule, 2003-2012

Dependent Variable: Log(salary schedule of districts)

VARIABLES	(1) OLS BA+0 exp	(2) OLS MA+0 exp	(3) OLS BA+10 exp	(4) OLS MA+10 exp	(5) IV BA+0 exp	(6) IV MA+0 exp	(7) IV BA+10 exp	(8) IV MA+10 exp
Collective bargain	0.025	0.047*	0.081***	0.119***	0.056**	0.080**	0.132***	0.173***
	(0.018)	(0.026)	(0.023)	(0.028)	(0.024)	(0.033)	(0.035)	(0.032)
Meet and confer	0.014	0.036*	0.019	0.046**	0.035**	0.058**	0.053**	0.082***
	(0.012)	(0.021)	(0.013)	(0.019)	(0.013)	(0.024)	(0.025)	(0.021)
% Hispanic students	0.119***	0.100**	0.081*	0.076	0.128***	0.109**	0.095**	0.092*
	(0.036)	(0.049)	(0.047)	(0.061)	(0.033)	(0.043)	(0.042)	(0.050)
% Black students	0.026	0.030	0.013	0.011	0.043*	0.047*	0.040	0.052*
	(0.026)	(0.025)	(0.026)	(0.028)	(0.026)	(0.027)	(0.024)	(0.030)
% Asian students	0.356***	0.360***	0.277***	0.305***	0.353***	0.356***	0.272***	0.297***
	(0.062)	(0.075)	(0.083)	(0.091)	(0.062)	(0.076)	(0.079)	(0.086)
% Other students	0.092**	0.098**	0.015	0.053	0.089**	0.095**	0.010	0.046
	(0.040)	(0.044)	(0.052)	(0.073)	(0.039)	(0.042)	(0.049)	(0.066)
Log(enrollment)	-0.043***	-0.042***	-0.057***	-0.050***	-0.040***	-0.038***	-0.052***	-0.043***
	(0.014)	(0.015)	(0.016)	(0.016)	(0.014)	(0.014)	(0.015)	(0.014)
Free lunch	-0.046**	-0.048*	-0.047	-0.053*	-0.039*	-0.040*	-0.035	-0.034
	(0.021)	(0.024)	(0.032)	(0.032)	(0.021)	(0.024)	(0.034)	(0.033)
Log(CWI)	0.443***	0.458***	0.559***	0.564***	0.430***	0.445***	0.538***	0.534***
	(0.068)	(0.062)	(0.098)	(0.099)	(0.070)	(0.063)	(0.095)	(0.098)
Log(school days)	0.413**	0.361*	0.693***	0.580***	0.405**	0.353*	0.679***	0.560***
	(0.191)	(0.195)	(0.196)	(0.198)	(0.184)	(0.187)	(0.188)	(0.188)
Log(revenue)	0.074***	0.071***	0.085***	0.081***	0.070***	0.0672***	0.078***	0.072***
	(0.017)	(0.017)	(0.018)	(0.018)	(0.016)	(0.016)	(0.018)	(0.016)
Instruments for CB					Mandatory CB law and union density>0.5			
First-stage F-statistic					345.97	350.16	90.38	76.47
J-statistic					1.108	1.092	3.661	2.995
(p-value)					(0.293)	(0.296)	(0.055)	(0.083)
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Observations	11,700	11,670	11,600	11,650	11,700	11,670	11,600	11,650
Adjusted R^2	0.635	0.619	0.603	0.623	0.630	0.614	0.593	0.603

Note: Errors are clustered within states (presented in parentheses). $^{***}p < 0.01$,$^{**}p < 0.05$, $^{*}p < 0.1$. The data source is the district-teacher matched 2003-2012 SASS panel data. Other covariates include teachers' race and ethnicity in percent, census regions and urbanism of districts that schools are located in. The number of observations is different for each OLS model from columns (1) through (4) and columns (5) through (8) because the information on the particular salary schedule is not available for some districts.

Since teachers join unions even when the legal setting is not favorable for unions, the size of the union membership in each district can measure the strength of unionism in the absence of CB. Moreover, the effect of union density on teacher salary may depend on the contractual status between unions and districts.

Table 5 presents the estimated effect of union density on base salaries, mostly determined by the educational level and experience of teachers, by contractual status. Columns (1) and (2) report the estimated effects of union density for all districts regardless of contractual status. In Column (1), a 10 percent increase in union density is predicted to raise base salary by 2 percent. Column (2) adds the state fixed effects to column (1). The magnitude of the effect of union density considerably declines, but the coefficient is still significantly positive at the 1 percent level. One limitation of the state fixed effects models is the lack of within-state variation in union density for certain states. According to the author's calculation, the average union density in the High-CB group between 2003 and 2012 is approximately 90 percent and does not vary much over time, suggesting that state fixed effects models will pick up the union effects mostly from other groups with greater within-state variation but a lower average density.

The results for districts with CB contracts ("CB districts") are reported in columns (3) and (4), for districts with MC agreements ("MC districts") in columns (5) and (6), and for districts with no agreement ("NA districts") in columns (7) and (8). The effect of union density is similar in magnitude for the CB districts and MC districts. Without state fixed effects, an increase in union density by 10 percent raises base salary by about 2 percent in both types of districts, but state fixed effects reduce the union effects by half. In the NA districts, union density still has a significantly positive effect, though smaller than that in CB or MC districts, on base salaries. Even with state fixed effects, a 10 percent increase in union density is predicted to raise the base salary by 0.5 percent.

Tables 3 through 5 show that CB significantly raise teacher pay. The size of the union membership, no matter the legal setting for CB, also has a positive impact on teacher pay. This is consistent with literature demonstrating that teachers unions raise teacher salaries (Hoxby, 1996; Lemke, 2004; Hirsh, Macpherson, and Winters, 2011), and that unionized teachers earn higher salaries (Baugh and Stone, 1982; Moore and Raisian, 1987; Freeman and Valletta, 1988; Belman, Heywood, and Lund, 1997).[33]

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will raise teacher salary much more for districts that have high union density than for districts that have low union density, because the former is more likely to achieve a CB agreement than the latter, once CB is legalized. Thus, IV estimation will measure the LATE for districts that are more likely to obtain bargaining contracts after CB becomes legal ("compliers"), but neither for districts that will never establish CB nor for those that will always have CB.

[33]They find that the union wage premium ranges between 10 and 15 percent of non-union wages. Using the SASS 2011-2012 teacher-level data, I also find that union teachers earn 11 percent higher base salaries

Table 5: Estimates of the Effect of Union Density on Teacher Base Salary, 2003-2012

Dependent Variable: Log(teacher base salary of districts)

VARIABLES	(1) All disricts	(2) All disricts	(3) CB districts	(4) CB districts	(5) MC districts	(6) MC districts	(7) NA districts	(8) NA districts
Union density	0.200***	0.094***	0.257***	0.118***	0.201***	0.126***	0.071**	0.055**
	(0.033)	(0.021)	(0.045)	(0.028)	(0.040)	(0.026)	(0.031)	(0.023)
Log(enrollment)	-0.049**	-0.022**	-0.042*	-0.024**	-0.086**	-0.041*	-0.014	0.001
	(0.023)	(0.009)	(0.023)	(0.010)	(0.032)	(0.022)	(0.035)	(0.023)
Free lunch	-0.036	-0.066***	-0.029	-0.073***	-0.035	-0.082**	-0.030	-0.056***
	(0.025)	(0.013)	(0.032)	(0.014)	(0.034)	(0.036)	(0.027)	(0.017)
Log(CWI)	0.502***	0.224**	0.541***	0.291**	0.710***	0.446***	0.264**	0.075**
	(0.117)	(0.088)	(0.142)	(0.110)	(0.080)	(0.123)	(0.118)	(0.037)
Log(school days)	0.755***	0.108	0.981***	0.258**	0.582**	0.239	0.417*	-0.075
	(0.222)	(0.110)	(0.271)	(0.109)	(0.265)	(0.189)	(0.253)	(0.252)
Log(revenue)	0.104***	0.071***	0.097***	0.072***	0.132***	0.087***	0.069*	0.044
	(0.025)	(0.010)	(0.024)	(0.012)	(0.036)	(0.029)	(0.037)	(0.027)
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
State FE		YES		YES		YES		YES
Observations	10,500	10,500	6,190	6,190	1,260	1,260	3,060	3,060
Adjusted R^2	0.575	0.698	0.552	0.667	0.620	0.742	0.486	0.659

Note: Errors are clustered within states (presented in parentheses). $^{***}p < 0.01$,$^{**}p < 0.05$, $^{*}p < 0.1$. The data source is the district-teacher matched 2003-2012 SASS panel data. Other covariates include race and ethnicity of teachers and of students in percent, census regions, and urbanism of the districts that schools are located in.

6.2 The Effect of Teachers Unions on Teacher Dismissal

The prediction of the model is that districts fire more teachers with dissatisfactory performance during a probationary period if they need to pay higher salaries to their permanent teachers. One may conjecture that districts only dismiss non-tenured teachers to grant greater job security to underperforming tenured teachers. To test these hypotheses, I estimate the union effects on the job security of both non-tenured and tenured teachers.

Table 6 reports the estimated effects of teacher pay on total teacher dismissal using the SASS panel data. The dependent variable is the number of total dismissed teachers due to poor performance divided by the number of all teachers (in hundreds) in each district. Columns (1) though (4) show that more teachers are dismissed in high-paying districts than in low-paying districts. An increase in salary schedules by 10 percent raises the dismissal rate by 2-3 percent. Adding the state fixed effects in columns (5) through (8) results in the same pattern that teacher pay significantly raises the dismissal rate of underperforming teachers. This is consistent with the model predicting that districts paying high teacher salaries have less tolerance of low-quality teachers because higher pay provides strong motivation for districts to select better teachers.

The coefficients for salary schedules of less experienced teachers are higher than those of more experienced teachers, implying that the salary effects on dismissal rates are greater if districts pay high salaries to novice teachers than to experienced teachers. This suggests that districts paying high salaries to less experienced teachers are more likely to dismiss low-quality teachers than districts paying high salaries to more experienced teachers. What we observe here is that, through the dismissal process, districts are allocating their resources from less experienced teachers to more experienced teachers.

Table 6 predicts that disadvantaged districts, indicated by the large proportion of students eligible for free/reduced-price lunches, are more likely to dismiss teachers for poor performance. Disadvantaged districts tend to have fewer financial resources and therefore have a greater motivation to either dismiss teachers with unsatisfactory performance during the probationary period or impose stricter standards for tenure. This is confirmed by significantly negative coefficients for log of district revenue. Another explanation might be that disadvantaged districts hire more teachers with temporary status or alternative certificates due to teacher shortage problems, and those teachers are more likely to be underprepared. This is consistent with Goldhaber, Lavery, and Theobald (2015), who show that disadvantaged students are more likely to be taught by low-quality teachers with fewer years of experience and lower licensure exam scores. The number of newly hired teachers is positively associated

than non-union teachers.

Table 6: Estimates of the Effect of Teacher Pay Level on Teacher Dismissal, 2003-2012

Dependent Variable: Total number of teachers dismissed due to poor performance / all teachers (in hundreds)

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log(BA and 0 exp)	3.012**				3.599*			
	(1.385)				(2.102)			
Log(MA and 0 exp)		2.614**				3.192**		
		(1.137)				(1.598)		
Log(BA and 10 exp)			1.510				1.639	
			(1.245)				(1.510)	
Log(MA and 10 exp)				1.932*				2.177*
				(1.144)				(1.302)
% Hispanic students	-0.235	-0.091	0.10	0.071	-0.076	-0.080	0.107	0.008
	(1.543)	(1.527)	(1.498)	(1.504)	(1.719)	(1.737)	(1.723)	(1.733)
% Black students	0.063	0.082	0.171	0.092	1.117	1.124	1.128	1.077
	(0.890)	(0.881)	(0.881)	(0.881)	(0.754)	(0.762)	(0.781)	(0.781)
% Asian students	-4.275	-4.038	-3.455	-3.685	-4.196	-4.119	-3.848	-4.049
	(4.253)	(4.266)	(4.315)	(4.334)	(4.132)	(4.152)	(4.216)	(4.234)
% Other students	4.247	4.383	4.525	4.488	1.575	1.619	1.761	1.682
	(2.688)	(2.674)	(2.729)	(2.698)	(3.078)	(3.074)	(3.021)	(3.057)
Enrollment/10,000	0.014	0.014	0.010	0.014	0.013	0.014	0.010	0.013
	(0.022)	(0.023)	(0.022)	(0.022)	(0.019)	(0.019)	(0.019)	(0.019)
Free lunch	1.470*	1.421*	1.269	1.332*	1.564*	1.557*	1.398*	1.492*
	(0.838)	(0.820)	(0.812)	(0.803)	(0.860)	(0.859)	(0.850)	(0.862)
Log(revenue)	-0.954***	-0.942***	-0.906***	-0.964***	-1.153***	-1.156***	-1.101***	-1.147***
	(0.193)	(0.209)	(0.218)	(0.229)	(0.166)	(0.171)	(0.182)	(0.184)
New teacher	0.261	0.258	0.258	0.288	0.312*	0.323*	0.316*	0.332*
	(0.177)	(0.186)	(0.197)	(0.199)	(0.185)	(0.188)	(0.192)	(0.191)
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
State FE					YES	YES	YES	YES
Observations	5,210	5,210	5,210	5,210	5,210	5,210	5,210	5,210
Adjusted R^2	0.021	0.020	0.020	0.020	0.033	0.033	0.033	0.033

Note: Errors are clustered within states (presented in parentheses). ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. The data source is the teacher matched 2003-2012 SASS panel data. Other covariates include log(number of school days), log(CWI) race and ethnicity of teachers in percent, census regions, and urbanism of the districts that schools are located in.

with dismissal rates, controlling for student enrollment size, suggesting that districts that hire more teachers also dismiss more teachers, keeping teacher employment stable.

Since districts with strong unionism pay higher wages, thus raising the dismissal rate, we expect that unionism is positively linked to teacher dismissal, other things constant. As seen in Table 6, the number of new teachers is positively associated with dismissal, so the flow of incoming and outgoing teachers describes the employment pattern in each district. Figure 2 illustrates the average ratio between teacher dismissal and new hire, measured by the number of dismissed teachers due to poor performance divided by the number of newly hired teachers in each district, computed from the district-level SASS data for 2011-2012, by legal environment. Blue bars represent the dismissal ratio of non-tenured teachers and red bars that of tenured teachers. The ratio is much higher for non-tenured teachers than for tenured teachers in all groups, reflecting the presence of a tenure system in all states regardless of unionism. The dismissal ratio for non-tenured teachers is greatest in the High-CB group and smallest in the No-CB group. In the High-CB group, about three non-tenured teachers for every ten newly hired teachers are dismissed due to poor performance, but the number is less than two for every ten in the No-CB group. For tenured teachers, however, the dismissal ratio is greatest in the No-CB group, though smallest in the Low-CB group.

Figure 2: The Ratio of Teacher Dismissal to New Hire by Group, 2011-2012

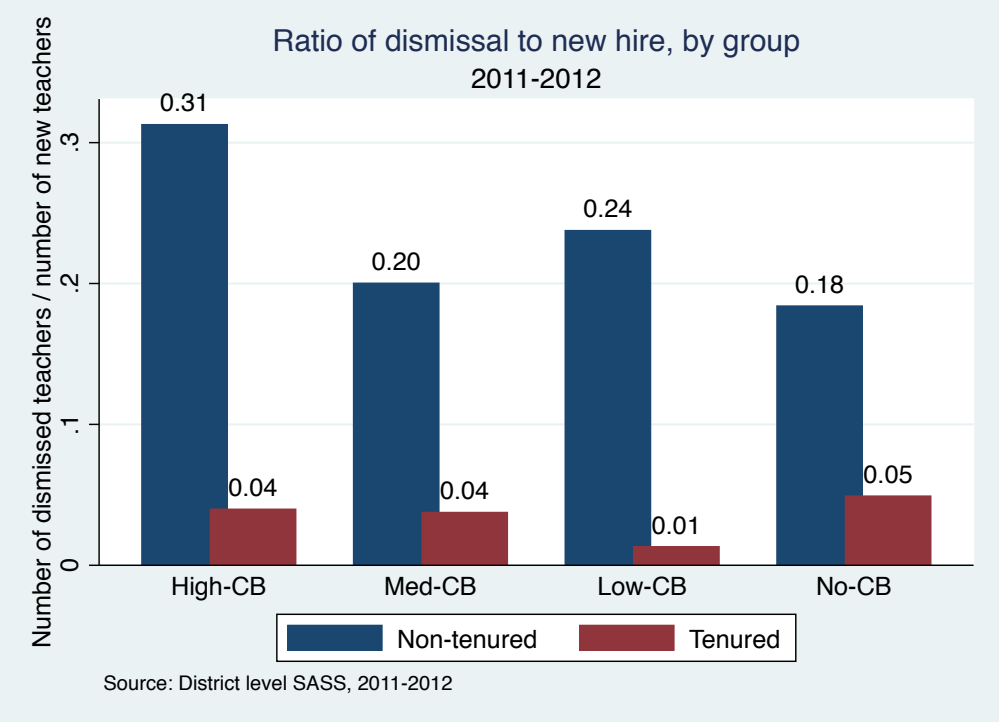


Table 7, which reports the estimates of the effects of unionism on teacher dismissal, is split into two parts. The first five columns present results for non-tenured teachers and the next five columns for that of tenured teachers. I use the same dependent variable and same covariates with Table 6. Column (1) shows that the legality of CB is positively associated with the dismissal rate of teachers. Compared to the No-CB group, other groups that allow CB have higher dismissal rates. In column (2), CB districts have higher dismissal rates compared to no-agreement districts. Column (3) reports the result from the IV regression, using legality of bargaining law, agency shop, and at least 50 percent in union density as instruments for CB. The IV result, giving a considerably higher estimate than the OLS estimate, shows that CB districts dismiss 1.5 more teachers for every 100 teachers than no-agreement districts. MC also has a significantly positive impact on the teacher dismissal rate. Column (4) shows that union density raises the dismissal rate of non-tenured teachers. Adding the state fixed effects in column (5) reduces the predicted effect of union density on the dismissal rate, but the estimated coefficient still remains significantly positive. When I include base salary and its interaction terms with union measures as an additional control variable to columns (1) though (5) for a robustness check, the coefficients of CB and union density appreciably fall, suggesting that teacher pay is the essential factor that districts consider in their decision for the dismissal of underperforming teachers. Therefore, the results in columns (1) through (5) in Table 7 support the hypothesis that teachers unions raise the dismissal rate of non-tenured teachers as they bargain for higher teacher salaries, giving greater incentives for districts to sort out better teachers.

One may argue that teachers unions support a more complicated due process for teacher dismissal, in order to lower the dismissal rate of tenured teachers. I find no evidence to support such a claim. The effect of unionism on the dismissal of tenured teachers is not statistically significantly different from zero, according to columns (6) through (10). The F-test in column (6) shows that there is no statistical difference in the dismissal rate among all groups. The IV estimation for the effect of CB in column (8) gives a statistically insignificant but positive sign. Union density in columns (9) and (10) also shows positive but insignificant impact on dismissal rates. Adding teacher salary and its interaction terms with union measures to columns (5) through (8) does not change the pattern.

In sum, the findings in Table 7 go against the common belief that unions hinder districts from firing low-quality teachers. Instead, the evidence is consistent with the model prediction that unions provide incentives to districts to distinguish high-quality teachers from low-quality teachers. Teachers unions raise the dismissal of less effective teachers during the probationary period so that districts can pay higher salaries to teachers whose teaching quality is proven to be above districts' performance standards.

Table 7: Estimates of the Effects of Teachers Unions on Teacher Dismissal, 2003-2012

Dependent Variable: Number of teachers dismissed due to poor performance / all teachers (in hundreds)

	Panel A: Non-tenured teachers' dismissal rate					Panel B: Tenured teachers' dismissal rate				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
VARIABLES	OLS	OLS	IV	OLS	State FE	OLS	OLS	IV	OLS	State FE
High-CB	0.696***					-0.260				
	(0.244)					(0.429)				
Med-CB	0.681***					0.375				
	(0.251)					(0.462)				
Low-CB	0.884***					-0.204				
	(0.277)					(0.485)				
Collective bargain		0.351*	1.501***				-0.517	0.247		
		(0.193)	(0.499)				(0.450)	(0.355)		
Meet and confer		0.274	1.071***				-0.385	0.121		
		(0.194)	(0.407)				(0.510)	(0.421)		
Union density				0.355**	0.238*				0.123	0.577
				(0.169)	(0.123)				(0.822)	(1.272)
First-stage F-stat.			182.84					182.84		
J-statistic			2.942					3.773		
(p-value)			(0.230)					(0.152)		
F-stat testing all coefficients of group dummies are zero						0.64				
(p-value)						(0.590)				
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	5,250	5,250	5,250	4,580	4,580	5,250	5,250	5,250	4,580	4,580
Adjusted R^2	0.123	0.111	0.076	0.068	0.171	0.020	0.020	0.019	0.011	0.023

Note: Errors are clustered within states (presented in parentheses). $^{***}p < 0.01$,$^{**}p < 0.05$, $^{*}p < 0.1$. The data source is the district-teacher matched 2003-2012 SASS panel data. Other covariates include race and ethnicity of teachers and of students in percent, total student enrollment grades K-12(in ten thousands), fraction of students eligible for free or reduced-price lunch programs, log(CWI), log(number of school days), log(revenue), number of newly hired teachers, census regions, and urbanism of the districts that schools are located in. Columns (4), (5) (9), and (10) have fewer observations than others because union density of each district is computed using the teacher-level SASS and some teachers do not report their union status. The instruments for CB are legality of CB, agency shop, and union density> 0.5.

6.3 The Effect of Teachers Unions on Teacher Attrition

I now turn to the analysis on voluntary teacher turnover. Ingersoll (2001) points out that the major source of school staffing problems in classrooms is not because public schools have teacher shortages, but because qualified teachers leave the teaching sector. His finding suggests that designing good teacher hiring programs is essential in improving educational outcomes, but reducing the attrition rate of incumbent teachers also deserves equally important attention. For this matter, several empirical studies document the extent of teacher attrition and attempt to identify who is more likely to leave teaching (Murnane et al.,1991; Weiss and Boyd, 1990; Bobbitt et al., 1994; Grissmer and Kirby, 1992 and 1997; Hanushek, Kain, and Rivkin, 2004).

My study contributes to the literature by asking former teachers whether unionism influences their decision to leave teaching. I test whether teachers unions reduce teacher attrition as they negotiate higher salaries for their teachers, using the cross-sectional 2011-2013 SASS-TFS data. I use a binary dependent variable indicating if a teacher in the 2011-2012 school year has voluntarily quit teaching during the 2012-2013 school year.

Table 8 gives the result of the estimated relation between teacher pay and quit probability. Column (1) indicates that teachers are less likely to quit if they earn a higher base salary.[34] A 10 percent increase in base salary is associated with a 0.2 percent lower quit rate, and it is statistically significant at the 1 percent level. This result is consistent with literature showing that working conditions significantly affect employees' voluntary job termination (Price, 1997 and 1989; Mueller and Price, 1990; Hom and Griffeth, 1995; Steer and Mowday, 1981). In particular, Goodlad (1984) and Rosenholtz (1989) find that a compensation scheme is strongly associated with teacher turnover.

To what extent does unionism contribute to the negative association between teacher pay and teacher attrition? According to column (2) in Table 8, teachers in districts where CB is allowed are more likely to remain in teaching than teachers in districts where bargaining is prohibited. Column (3) shows that the quit probability is 2 percent lower in CB districts and 1.5 percent lower in MC districts compared to no-agreement districts. Column (4) reports the IV estimate of the effect of unionism on teacher attrition, using legality of CB, agency shop, and majority rule of union density as excluded instruments for CB. As seen in the large first stage F-statistic and small p-value for over-identification test, these instruments are valid. The IV estimates for contractual status are slightly greater (more negative) than OLS estimates in magnitude. They show that CB and MC reduce teacher attrition by 3 percent and 2 percent, respectively.

[34] Base salary is mostly determined by the educational level and teaching experience of individual teachers, so I do not control for these variables in model (1).

Table 8: Estimates of the Effects of Teachers Unions on Voluntary Job Termination, 2011-2013

Dependent Variable: Binary variable indicating if a teacher has left teaching career

VARIABLES	(1) OLS	(2) OLS	(3) OLS	(4) IV	(5) OLS	(6) OLS	(7) Dist. FE	(8) OLS
Log(base salary)	-0.022***							-0.015***
	(0.005)							(0.005)
High-CB		-0.026***						
		(0.005)						
Med-CB		-0.012**						
		(0.005)						
Low-CB		-0.015***						
		(0.005)						
Collective bargain			-0.021***	-0.028***				-0.018***
			(0.004)	(0.010)				(0.004)
Meet and confer			-0.015***	-0.020**				-0.014***
			(0.005)	(0.009)				(0.005)
Union density					-0.017***			
					(0.005)			
Union member						-0.011***	-0.007***	-0.004
						(0.004)	(0.002)	(0.004)
Master's and above		0.005*	0.004	0.004**	0.003	0.003	0.009***	
		(0.003)	(0.003)	(0.002)	(0.003)	(0.003)	(0.003)	
Full time	-0.028**	-0.035***	-0.034***	-0.035***	-0.034***	-0.033***	-0.027***	-0.030**
	(0.012)	(0.011)	(0.011)	(0.009)	(0.011)	(0.011)	(0.003)	(0.012)
Experience		-0.002***	-0.002***	-0.002***	-0.002***	-0.002**	-0.001***	
		(0.0006)	(0.0006)	(0.0005)	(0.0006)	(0.0006)	(0.001)	
Observations	28,570	28,570	28,570	28,570	28,570	28,570	28,570	28,570
Adjusted R^2	0.013	0.019	0.018	0.018	0.015	0.016	0.017	0.016

Note: Errors are clustered within districts (presented in parentheses). $^{***}p < 0.01$,$^{**}p < 0.05$, $^{*}p < 0.1$. The data source is the district-teacher matched SASS-TFS data for 2011-2013. Other covariates include gender experience^2, interaction between experience and gender and experience^2 and gender, a dummy for secondary school, log(number of days in the school year), log(total student enrollment grades K-12), log(CWI), log(revenue), fraction of students eligible for free or reduced-price lunch programs, students' ethnicity and race, census regions, and urbanism of the school districts that schools are located in. The instruments for CB are legality of CB, agency shop, and union density> 0.5. The instruments are both relevant and exogenous; the first stage F-statistic is 173.77, and the J-statistic is 4.103 with the p-value of 0.134.

In column (5), regardless of the legal setting for CB, teachers in districts with higher union density are more likely to remain in teaching. A 10 percent increase in union density is associated with a 0.2 percent decrease in quit probability. Column (6) shows that unionized teachers are 1 percent less likely to quit relative to their otherwise comparable non-union colleagues. This estimate will be biased if teachers in high-paying districts (partly due to the presence of CB) are more likely to join unions and less likely to quit teaching than teachers in low-paying districts. In column (7), I add the district fixed effects to reduce such selection bias, and the effect of union membership on the attrition rate slightly falls but still remains significantly negative.

As a robustness check, I add base salary to regression models (2) through (7), and the results do not differ from those shown in Table 8, suggesting that unionism affects teacher attrition, independent of pay level. This is consistent with studies showing that teachers unions influence teachers' well-being beyond their salaries. Han (2013) finds that teachers covered by CB or MC agreements receive greater non-wage benefits, such as better retirement plans, than teachers under no such agreement. Better fringe benefits and working conditions in highly unionized districts may also encourage teachers to stay in the teaching sector (Retsinas, 1982; Freeman, 1986; Eberts, 1987;Murphy, 1990; Moe, 2001; Johnson, 2004). When I include all major determinants of teacher turnover in column (8), union membership loses its significance, suggesting that the union effects on teacher attrition is mainly through contractual status and pay level. The estimates in Table 8 are, therefore, consistent with the hypothesis that teachers unions reduce teacher attrition.

Researchers find that teacher attrition follows a U-shaped curve, describing the pattern that young and old teachers have a high turnover rate while mid-career teachers have a low turnover rate (Bobbitt et al., 1994; Boe et al., 1997 and 1998; Grissmer and Kirby, 1987). My data also show that full-time and experienced teachers are more likely to remain in teaching, suggesting attrition is a predominant problem among entry-level teachers.[35]

To investigate the sensitivity of the results from the 2011-2013 SASS-TFS data, I re-estimate the union effects on teacher attrition using the 2007-2009 SASS-TFS data.[36] The alternative result is similar to Table 8, although the effect of MC on quit rates is not significantly different from zero. See Table A1 in Appendix I for the result. In addition, when I focus on novice teachers whose experience is five years or less, the union effects on teacher attrition is much greater. Table A2 in Appendix I reports this result. The magnitudes of the negative coefficients of all union measures are greater for these less experienced teachers. No

[35]As I exclude teachers who left teaching for retirement in the analysis on teacher quits, the data do not show this U-shaped relationship. However, I do find the U-shaped relationship in the full sample as indicated by the significant coefficient of the quadratic term of experience.

[36]The 2004-2005 TFS data, however, provides no information regarding who voluntarily left teaching.

matter how and when I measure unionism, I find that teachers unions lower teacher attrition.

A high level of teacher attrition may not be necessarily detrimental to average teacher quality if there is an equal chance of voluntary quits for low-quality and high-quality teachers or if low-quality teachers are more likely to quit. However, many studies find that teachers with higher ability or stronger qualifications have a greater chance of leaving the teaching force (Podgursky, Monroe, and Watson, 2004; Lankford, Loeb, and Wyckoff, 2002; Stinebrickner, 2001a and 2001b; Henke, Chen, and Geis, 2000; Murnane et al., 1991; Schlechty and Vance, 1981). Han (2012) also finds that high-quality teachers, measured by higher wage levels from their outside options in non-teaching occupations, tend to leave the teaching sector more than low-quality teachers. My data also show this pattern. In Table 8, the "Masters' and above" (teachers with master's degrees or above) shows a positive association with teacher attrition, and this association is even stronger in the 2007-2009 SASS-TFS data (see Table A1 in Appendix I).[37]

According to the author's calculations using the TFS for 2008-2009 and 2012-2013, most teachers who left teaching found better outside options. More than 70 percent of teachers said the salary in their new job is at least as good as in teaching, 75 percent said their job security is at least as good as in teaching, and more than 90 percent said their overall working conditions are at least as good as in teaching. This finding also suggests that teachers who quit are more likely to be higher-quality teachers, supporting the claim that average teacher quality would fall as more teachers leave their teaching careers.

6.4 The Effect of Teachers Unions on Teacher Quality and Education Quality

Thus far, this study shows that unionism raises the dismissal rate of low-quality teachers while lowering the quit rate of high-quality teachers. The model predicts that this dynamic in teacher turnover will ultimately have a positive impact on teacher quality in highly unionized districts. To test this hypothesis, I estimate the union effects on the likelihood of being certified as HQT.

Table 9 presents the results from this estimation using the 2011-2013 SASS-TFS data. Column (1) shows that teachers who earn higher base salaries are more likely to be qualified as HQT. A 10 percent increase in base salary raises the probability of being HQT by 1.2 percent. Column (2) shows that teachers in districts with mandatory CB laws have a significantly

[37]This may be partly due to different labor market conditions between 2007-2008 and 2011-2012. In 2011-2012, the economy was still in a recession, perhaps causing many teachers with a high level of education who were considering leaving the teaching sector to remain in their classrooms, as they may have encountered difficulty finding jobs in other sectors.

higher chance of being certified as HQT compared to those in districts that ban CB. The HQT probability is 5 percent higher for teachers in the High-CB group and 3 percent higher in the Med-CB group, relative to the HQT probability for teachers in the No-CB group. In column (3), teachers covered by bargaining contracts have a significantly higher chance of being HQT than teachers covered by no agreement. The IV estimation in column (4) shows that CB significantly raises the HQT probability by 6 percent. MC also raises the HQT probability by 4 percent.

Regardless of contractual status, according to column (5), the increase in union density by 10 percent significantly raises the HQT probability by 0.3 percent. Column (6) shows that union teachers are 3 percent more likely to be HQT than otherwise comparable non-union teachers. This estimate is subject to selection bias if teachers in bargaining districts are more likely to join unions and if they are more likely to be HQT than teachers in no-agreement districts. A district fixed effects model in column (7) reduces this selection bias, and the results are similar to those presented in column (6).

As a robustness check, I add teacher salary as an additional control variable to regression models (2) through (7). The alternative results show only a slight fall in the coefficients of union measures, suggesting that the indirect effect, through pay level, of unionism on HQT is insignificant. When I control for the dismissal rate of non-tenured teachers, the coefficients of the dismissal rates are significantly positive and the coefficients of unionism appreciably fall. This indicates that teacher dismissal is an important mechanism for districts' quality control of teachers. Finally, column (8) shows that the union effects on HQT is mainly via union membership of teachers, not via bargaining contracts. HQT is not a perfect measure for teacher quality, but to the extent that HQT can capture certain characteristics of good teachers, the results in Table 9 show that unionism raises teaching standards, thereby raising average teacher quality.

I also estimate the effect of unionism on HQT using the 2007-2009 SASS-TFS data for a sensitivity check (see Table A3 in Appendix I for results). The effect of the legality of CB on HQT is no longer positive, and the effect of bargaining contracts is statistically insignificantly different from zero. However, teacher salaries, union membership, and union density still show a significantly positive impact on HQT.[38]

Table 9 predicts that more educated, more experienced, and full-time teachers are more likely to be HQT. Female teachers have a higher likelihood of being HQT. Teachers in disadvantaged districts and in districts with low revenues are more likely to be HQT. These districts have strong incentive to enforce stricter standards for teachers, as it is relatively

[38]Sensitivity check with the 2004-2005 TFS data is unavailable because it has no information on HQT.

Table 9: Estimates of the Effects of Teachers Unions on Teacher Quality, 2011-2013

Dependent Variable: Binary variable for High Quality Teacher (HQT)

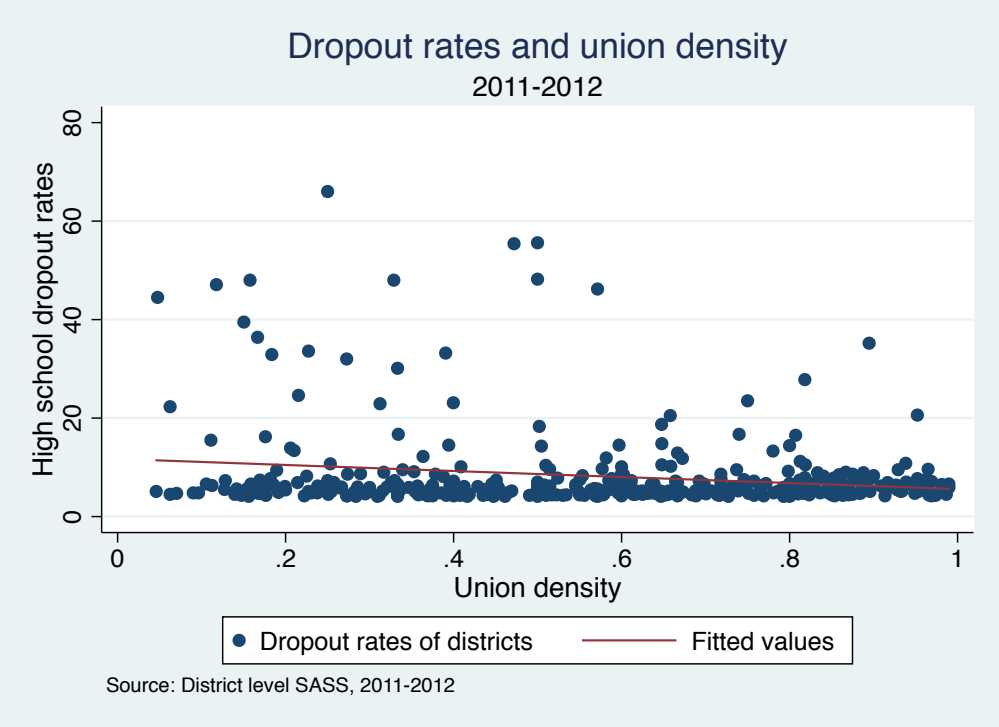
VARIABLES	(1) OLS	(2) OLS	(3) OLS	(4) IV	(5) OLS	(6) OLS	(7) Dist. FE	(8) OLS
Log(base salary)	0.118***							0.112***
	(0.015)							(0.015)
High-CB		0.046**						
		(0.018)						
Med-CB		0.028*						
		(0.016)						
Low-CB		0.014						
		(0.015)						
Collective bargain			0.024*	0.061**				0.014
			(0.014)	(0.024)				(0.014)
Meet and confer			0.018	0.042**				0.013
			(0.018)	(0.021)				(0.018)
Union density					0.033*			
					(0.019)			
Union member						0.029***	0.028***	0.025***
						(0.009)	(0.006)	(0.009)
Master's and above		0.065***	0.065***	0.065***	0.064***	0.064***	0.061***	
		(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.009)	
Full time	0.055***	0.084***	0.084***	0.084***	0.083***	0.081***	0.109***	0.054***
	(0.019)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.009)	(0.019)
Experience		0.012***	0.012***	0.012***	0.012***	0.012***	0.003***	
		(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	
Male	-0.039***	-0.039*	-0.038*	-0.039*	-0.037*	-0.036*	-0.003	-0.038***
	(0.009)	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)	(0.008)	(0.009)
Free lunch	0.081***	0.076***	0.078***	0.078***	0.077***	0.077***	0.048***	0.081***
	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)
Log(revenue)	-0.019***	-0.019***	-0.020***	-0.024***	-0.019***	-0.019***	-0.020***	-0.020***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.007)	(0.006)
Observations	29,100	29,100	29,100	29,100	29,100	29,100	29,100	29,100
Adjusted R^2	0.028	0.035	0.035	0.034	0.035	0.035	0.128	0.029

Note: Errors are clustered within districts (presented in parentheses). $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$. The data source is the district-teacher matched SASS TFS data for 2011-2013. Other covariates include experience^2, interaction between experience and gender, and between experience^2 and gender, a dummy for secondary school, log(number of school days), log(total student enrollment grades K-12), log(CWI), race and ethnicity of teachers and of students, and urbanism of the districts that schools are located in. The instruments for CB are legality of CB, agency shop, and union density$>$ 0.5. The instruments are both relevant and exogenous; the first stage F-statistic is 137.8, and the J-statistic is 1.100 with the p-value of 0.577.

more costly for them to retain low-quality teachers.[39]

Since teacher quality is not the only factor that determines students' achievement and unionism can influence other educational inputs beyond teacher salaries, I investigate the direct effects of teachers unions on actual student performance. As no data on student performance by school district level with nationally representative samples is currently available, I use high school dropout rates as a measure of student achievement.[40] The high school dropout rate is defined as a percentage of students from grades 9-12 who were enrolled at some time during the school year and were expected to be enrolled in grades 9-12 in the following school year but were not enrolled by October 1 of the following school year.[41]

Figure 3: Relationship between Dropout Rates and Union Density, 2011-2012



[39]If so, higher teacher standards in disadvantaged districts may hurt educational outcomes of students if there is a teacher shortage problem, because they could exacerbate the teacher shortage problem by placing double burdens on teachers (challenging classroom environments and high standards). These districts will continue to be staffed with more temporary or substitute teachers who are less likely to meet standards. Table 6 has shown that these districts have higher dismissal rates. Disadvantaged districts hire more new teachers with less preparation in teaching and also dismiss more teachers for poor performance. This employment pattern, though a rational choice for districts, is more likely to hurt students' educational outcomes.

[40]When I examine the association between HQT and dropout rate, the effects of HQT on the dropout rate is insignificantly different from zero. This suggests that i) HQT is not measuring true teacher quality, and/or ii) teachers unions affect the dropout rate via channels other than teacher quality.

[41]Students who have graduated, transferred to another school, died, moved to another country, or who are out of school due to illness are not considered dropouts.

Figure 3 displays a weakly negative association between dropout rates and union density, using the district-teacher matched SASS data for 2011-2012. It Districts tend to have low dropout rates when their union density is high, but the distribution of dropout rates is more dispersed when union density is low.[42]

Table 10 reports the estimated effects of unionism on the high school dropout rate. In column (1), teacher salary appears to have no significant effect on the dropout rate. Column (2) shows that, on average, the High-CB group has a 5 percentage point lower dropout rate than other groups. In column (3), CB and MC significantly reduce the dropout rate. The IV regression in column (4) reports greater predicted effects of contractual status on the dropout rate, using the mandatory bargaining law and the majority rule of union density as instruments for CB. Collective bargaining and MC reduce the dropout rate by 6 percent and 4.5 percent, respectively. These effects are substantial, considering the standard deviation for dropout rates is about 11 percentage points. Column (5) shows that union density has a significantly negative effect on the dropout rate. A 10 percent increase in union density reduces the dropout rate by 0.4 percentage points. Column (6), which adds the interaction term of the contractual status and union density, shows that union density significantly reduces the dropout rate even in the districts with no agreement.

When I control for the dismissal rate of non-tenured teachers to column (1) through (6) as a robustness check, the coefficients on dismissal rates are statistically insignificant but negative, which suggests that districts dismissing more low-quality teachers tend to have higher students achievement. The coefficients on union measures, however, still remain significant. For the sensitivity test, I also run the same analysis using the SASS panel data covering 2003 through 2012. The estimated coefficients for the effect of unionism on the dropout rate are smaller in panel data, but the general pattern of the results is similar to those displayed in Table 10 (see Table A4 in Appendix I for the results).[43] Overall, the data show that unionism is predicted to reduce dropout rates, and this is consistent with literature presenting that unionism improves educational outcomes (Eberts and Stone, 1987; Kleiner and Petree, 1988; Vachon and Ma, 2015).[44]

[42]I dropped one outlier district whose dropout rate is greater than 80 percent and union density is about 50 percent.

[43]The average dropout rate is considerably higher in the 2011-2012 SASS than in previous SASS datasets. A cross-sectional analysis separately for 2003-2004 and 2007-2008 shows that the effect of teachers unions on the dropout rate is smaller in those years than in 2011-2012. This might be partly due to the different reactions of districts to the financial crisis. During the recession, unionized districts may have had stronger resistance or better responses to economic shock. Districts with strong unionism may be able to retain more high-quality teachers during a recession, as fewer outside options become available. Moreover, when districts have fewer resources, they may need to let go more low-quality teachers during the probationary period, granting tenure to only a few highly selected teachers. Further research will be necessary to identify the effect of the financial crisis on teacher turnover patterns and educational outcomes.

[44]Hoxby (1996) and Lovenheim (2009) present different findings regarding the union effects on the dropout

Table 10: Estimates of the Effects of Teachers Unions
on High School Dropout Rate, 2011-2012

Dependent Variable: High school dropout rates (in percent)

VARIABLES	(1) OLS	(2) OLS	(3) OLS	(4) IV	(5) OLS	(6) OLS
Log(base salary)	-0.809					
	(1.819)					
High-CB		-4.794***				
		(1.776)				
Med-CB		-1.990				
		(1.265)				
Low-CB		-1.417				
		(1.047)				
Collective bargain			-4.387**	-6.38***		-6.445***
			(1.759)	(2.224)		(2.374)
Meet and confer			-3.286***	-4.540***		-3.932***
			(1.166)	(1.390)		(1.411)
Union density					-4.376**	-4.314***
					(1.998)	(1.367)
CB*density						4.200**
						(1.932)
MC*density						2.069
						(2.048)
Observations	650	730	730	730	650	650
Adjusted R^2	0.277	0.338	0.337	0.323	0.300	0.421

Note: Errors are clustered within states (presented in parentheses). $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$. The data source is the district-level 2011-2012 SASS data for consistency with the analysis on teacher quits in Table 8 which uses the 2011-2013 SASS-TFS dataset. Other covariates include race and ethnicity of teachers and of students in percent, log(total student enrollment grades K-12), fraction of students eligible for free or reduced-price lunch programs, log(CWI), number of school days, log(revenue), census regions, and urbanism of the districts that schools are located in. Columns (1), (5), and (6) have fewer observations than others because base salary and union density of each district is computed using the teacher-level SASS, and some teachers do not report their union status. The instruments for CB are mandatory CB and union density> 0.5. The instruments are both relevant and exogenous; the first stage F-statistic is 51.74, and the J-statistic is 1.082 with p-value of 0.299.

6.5 The Effect of Restricting Teachers' Bargaining Rights on Teacher Turnover

If teachers unions increase the dismissal of underperforming teachers and reduce teacher attrition, any shock weakening unionism will lead to the opposite result in teacher turnover, in turn lowering average teacher quality. The unexpected legal change in 2010-2011 limiting the bargaining rights of teachers in Idaho, Indiana, Tennessee, and Wisconsin allows me to

rate. I discuss the inconsistency between the studies in Appendix II.

examine the causal effects of unionism on teacher turnover.[45] All four states had mandatory CB laws before the passage of new state legislation, but the new laws no longer require districts to bargain with unions, effectively moving them to the Low-CB group. I employ the difference-in-difference (DID) estimation, using these four states as a treatment group and the remaining states in the High-CB and Med-CB as a control group.

To test for the parallel-trend assumption of the DID model, Figure 4 plots teacher base salary of the treatment and control groups between 2003 and 2012. The 2003-2004 and 2007-2008 SASS display a stable time trend for both treatment and control groups before the legal change in 2010-2011. Although there are only three data points, the visual inspection shows that the parallel-trend assumption is satisfied.

Figure 4: Pre-treatment Trend for Teacher Base Salary

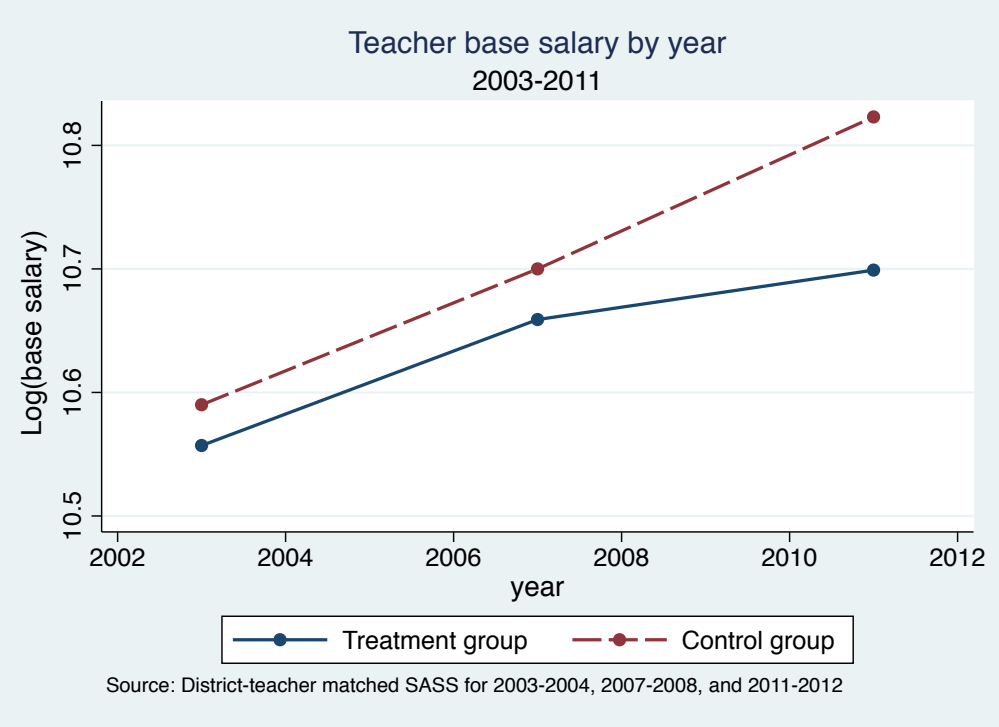


Table 11 shows the results from the DID estimation in four panels. Panel A presents the log of base salary of the treatment and control groups before and after the legal change. Teacher salaries rise in 2011-2012 compared to previous years (as salaries are indexed to inflation) in both groups, but the extent of pay increase of the treatment group is about half of the pay increase of the control group. Thus, the DID estimator shows that the legal

[45] In Indiana, state workers lost mandatory bargaining rights in 2005, but other public sector workers, including teachers, lost their rights in 2011.

change weakening unionism significantly reduces teacher salaries by 9 percent. I add control variables for the robustness check, and the magnitudes of the alternative DID estimator for log of base salary remain largely unchanged.

The legal changes in those four states only apply to public school teachers, so we should not observe any different pattern for salaries of private sector workers between the treatment and control groups. I compute the "placebo DID" estimator for the effect of legal change

Table 11: The Effect of Legal Changes Limiting Collective Bargaining Rights of Teachers on Base Salary, Teacher Turnover, and Teacher Quality, 2003-2012

	Before legal changes	After legal changes	Treatment effect= After−Before
Panel A: Log(Teacher Base Salaries)			
Treatment group	10.608	10.699	0.091
	(0.006)	(0.009)	(0.006)
Control group	10.644	10.823	0.179
	(0.004)	(0.005)	(0.006)
Difference (Treatment−Control)	-0.036	-0.123	-0.088***
	(0.007)	(0.011)	(0.024)
Panel B: Non-tenured Teachers' Dismissal			
Treatment group	0.061	0.153	0.092
	(0.007)	(0.015)	(0.017)
Control group	0.086	0.304	0.218
	(0.004)	(0.032)	(0.032)
Difference (Treatment−Control)	-0.024	-0.151	-0.126***
	(0.008)	(0.036)	(0.043)
Panel C: Teacher Attrition			
Treatment group	0.023	0.048	0.025
	(0.003)	(0.004)	(0.003)
Control group	0.021	0.034	0.013
	(0.001)	(0.001)	(0.001)
Difference (Treatment−Control)	-0.002	-0.014	0.012***
	(0.003)	(0.004)	(0.003)
Panel D: High Quality Teachers (HQT)			
Treatment group	0.866	0.735	-0.131
	(0.006)	(0.008)	(0.008)
Control group	0.882	0.783	-0.099
	(0.002)	(0.003)	(0.003)
Difference (Treatment−Control)	-0.016	-0.048	-0.032***
	(0.006)	(0.008)	(0.008)

Note: Clustered standard errors are presented in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$. The data sources are the district-teacher matched 2003-2012 SASS panel data for panel A and B and the SASS-TFS data for 2007-2009 and 2011-2013 for panel C and D. The treatment group includes WI, ID, IN, and TN. The control group includes other states in the High-CB and Med-CB groups that mandate CB.

on real wages of private sector workers to check the validity of the results in Panel A, using the March Current Population Survey (CPS) for 2004, 2008, and 2012. The placebo DID estimator is not statistically significantly different from zero, confirming that the legal change made the negative impact only on teachers, whose outcome the law was designed to influence (see Table A5 in Appendix I for the result of this estimation).

Panel B shows the dismissal rate of non-tenured teachers. Lower salaries provide less incentives for districts to sort out better teachers, so we expect to see lower dismissal rates in the treatment group. As the number of newly hired teachers should also be considered, I measure the dismissal rate by the number of dismissed non-tenured teachers divided by newly hired teachers. Both the treatment and control groups experience a substantial increase in dismissal rates in 2011-2012 (most likely due to the budget crisis in school districts), but the dismissal rate rises much more slowly in the treatment group than in the control group. The DID shows that the legal change reduces the dismissal rate by 12.6 percent relative to the control group.[46] When I add control variables for the robustness check, the alternative DID estimator remains almost the same.[47]

I present the estimated DID results for teacher attrition in Panel C. We expect higher teacher attrition in the treatment group, because lower salaries discourage teachers from staying in the teaching sector. Although teacher attrition rises in both the control and treatment groups, it doubles in the treatment group after the legal change. As indicated by a significantly positive DID estimator, the passage of new legislation in those four states raises teacher attrition by 1.2 percent, small but statistically significant at the 1 percent level. As the legal change weakens unionism and reduces teacher pay, teachers have greater motivation to leave teaching in those four states.

As the new laws lower the dismissal rate of underperforming teachers and raise teacher attrition in the treatment group, they are more likely to decrease teacher quality. Panel D presents the DID results for the HQT probability.[48] As predicted, the difference-in-difference estimator for HQT shows that the legal change significantly lowers teachers' likelihood of being certified as HQT in the four states by 3 percent.[49]

[46]The parallel trend assumption seems satisfied as the pre-treatment trend of dismissal rates are stable.

[47]For the original dismissal rate measured by the number of dismissed non-tenured teachers divided by all teachers (in hundreds), I estimate the DID using the equation (15) while controlling for covariates listed in the note of Table 7. The DID estimator is -0.350**(0.178).

[48]Testing for the parallel-trend assumption is unavailable for the DID model in Panels C and D because the information on HQT and teacher attrition is unavailable in the 2003-2004 SASS data.

[49]The DID estimation shows that the effect of the legal change on the high school dropout rate is insignificant. The SASS 2011-2012 may not capture the full effects of legal change on education output as it takes some time for the new law to be fully effective. The time lag can also weaken the effect of new laws on student achievement because the new laws must affect teacher turnover and teacher quality first before influencing students' performance.

Figure 5: The Effect of Legal Change on HQT Proportion

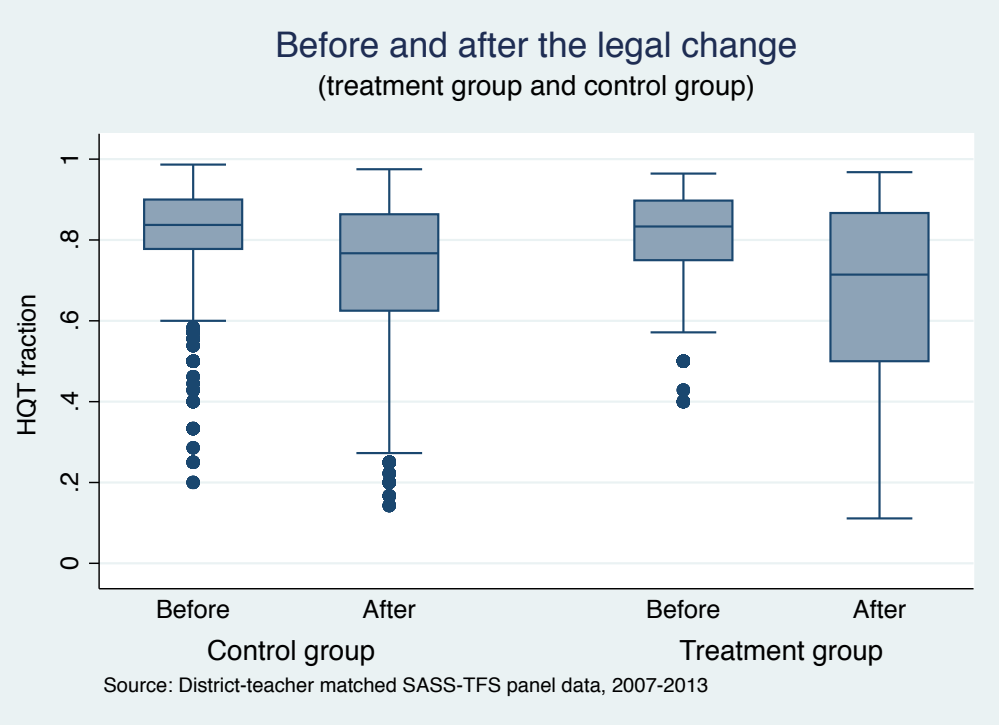


Figure 5 presents this causation using the box plots of the proportion of HQT in districts for the treatment and control groups before and after the legal change. The box plots for the treatment and control groups look similar before the legal change, except that there are more outliers in the control group because they have more observations than the treatment group. After the legal change, however, the box plot of the treatment group exhibits a wider range with a lower median, a lower first quartile, and a lower minimum than the box plot of the control group.

In sum, the empirical evidence confirms that unionism has a causal impact on the pattern of teacher turnover and, ultimately, on teacher quality. The data show that declining unionism, due to the recent legal changes limiting teachers' bargaining rights which successfully decrease teacher salary, decreases teacher quality, as low salary reduces districts' incentive for dismissal of low-quality teachers and discourages high-quality teachers to remain in schools.

7 Discussion and Policy Implications

This study has several important implications for educational reforms and policies. First, the results of this study suggest that the dismissal of underperforming teachers is an impor-

tant task for teacher quality control under the tenure system. I find that higher teacher pay gives school districts a strong incentive to be more selective in granting tenure to teachers. Districts paying high teacher salaries utilize the tenure system more efficiently as they dismiss more low-quality teachers, raising average teacher quality by setting higher standards. The high dismissal of high-paying districts will not discourage high-quality teachers from applying to positions in those districts because those teachers will receive tenure and greater lifetime earnings. As it is often challenging to accurately measure teachers' productivity, it may be beneficial for districts considering tenure system reform to implement a longer probationary period to better evaluate their teachers.

Second, with current compensation schemes and the unpopularity of the teaching profession, it is difficult to attract high-quality applicants into the teaching sector. Even if high-quality individuals start a teaching career, they are likely to leave for non-teaching occupations. Performance pay and a merit pay system are often considered as ways to motivate teachers and provide 'fair' compensation. However, they may not be able to convince high-quality teachers to stay until policymakers identify good criteria for evaluating teacher effectiveness. My study shows that teachers unions reduce teacher attrition by, among other mechanisms of unionism, raising the base salary of teachers. As long as districts can separate bad teachers from good teachers during probationary periods, adding extra pay to the base salary may appeal to high-quality teachers who respond to better compensation packages. Milanowski and Odden (2007) estimate that the cost of turnover for each teacher with one year of teaching experience is approximately \$9,000−\$23,000, and taxpayers pay at least \$4 billion to replace these teachers every year. These expenses may be avoided if they are instead used towards existing teacher salaries to retain high-quality teachers.

Third, the evidence in this study rejects the claim that teachers unions hurt educational quality by overprotecting the job security of low-quality teachers. In contrast, the data show that districts covered by bargaining contracts or with high union density dismiss more non-tenured teachers with unsatisfactory performance, and those districts have more qualified teachers than districts with no agreement with unions. I find no evidence that unionized districts dismiss fewer underperforming tenured teachers. Moreover, this study finds that unions favor a seniority pay system allocating resources from less experienced to more experienced teachers whose performance is already proven to be above standard. This suggests that the union's agenda is aligned with the district's interest in dismissing underperforming teachers and paying higher salaries to more experienced teachers. As high salaries are better matched with high-quality teachers, unions contribute to the improvement in teacher quality. This study also finds that unions reduce the dropout rates of districts. To the extent that the dropout rate of an area is negatively associated with future earnings and upward mobility

of children of the area (Chetty et al.,2014), unions are more likely to improve educational attainment and the welfare of all children in the area.

Lastly, I find that teachers unions can influence the educational system even when CB is not allowed. Union density, which measures the strength of unionism in the absence of bargaining contracts, is predicted to have a positive impact on teacher quality and student achievement. This is consistent with Freeman and Han (2013) and Han (2013) who find that teachers unions, even if deprived of bargaining rights, affect teachers' well-being. Unions' power is not solely based on whether they are able to obtain bargaining contracts. Thus, emphasizing CB will underestimate unions' roles and influence on educational systems.

It is noteworthy to consider a long-run consequence of the pattern of teacher turnover. If high-quality teachers prefer districts with strong unionism where pay is high but the dismissal risk during probationary periods is also high, the average quality of applicants will increase in those districts as those districts attract good teachers from districts with weak unionism. Over time, the match rent and overall level of human capital may fall in districts with weak unionism. As far as declining legal support for unionism is concerned in recent years, therefore, teacher quality may suffer if the decreasing trend persists.

8 Conclusion

This study examines the relation between teachers unions and teacher turnover and assesses union effects on US public schools. The significant contributions of this study to literature include the provision of a theoretical framework of unions' roles in both voluntary and involuntary teacher turnover, the diverse measurements of unionism from all 50 US states, the controls for various district-specific and teacher-specific demographics available from district-teacher matched data, and the use of panel data.

A simple two-period job matching model with positive renegotiation costs predicts that teachers unions raise the dismissal of low-quality teachers because higher wages give districts a greater incentive to select high-quality teachers but lower the attrition of high-quality teachers, as they negotiate higher wages for teachers. The unique district-teacher matched panel data enable me to utilize the within-state and within-district variation of unionism and instrumental variable regressions to identify the union effects on the educational system. The empirical evidence confirms these predictions. I find that districts with strong unionism dismiss more underperforming teachers and have lower teacher attrition than districts with weak unionism.

Through the dynamics of teacher turnover, unions ultimately raise teacher quality, as unionized districts can better retain good teachers and dismiss more underperforming teach-

ers. Two pieces of empirical evidence support this hypothesis: districts with strong unionism have more teachers with stronger qualifications and lower dropout rates than districts with weak unionism. I also find that the recent legal change weakening unionism in four states affects the teacher turnover pattern and teacher quality negatively, confirming unions' positive role in the US educational system.

This research, therefore, suggests that restricting the legal boundary for unions' activities may not be the appropriate approach in improving educational outcomes. Rather, promoting union-friendly environments may create more encouraging economic conditions for teachers and provide districts with incentives to select better teachers, eventually raising teacher quality. This study also shows that obtaining proper measures of unionism is critical for accurately estimating union effects. I should emphasize that collective bargaining is not a necessary condition for teachers unions to make a positive impact on public schools. Their collective "voice," assessed by union density, is another powerful mechanism that unions can wield in influencing the educational system.

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Appendix I Supplement Tables

Table A1: Estimates of the Effects of Teachers Unions on Voluntary Job Termination, 2007-2009

Dependent Variable: Binary variable indicating if a teacher has left teaching career

VARIABLES	(1) OLS	(2) OLS	(3) OLS	(4) IV	(5) OLS	(6) OLS	(7) Dist. FE
Log(base salary)	-0.015***						
	(0.005)						
High-CB		-0.017***					
		(0.004)					
Med-CB		-0.006					
		(0.004)					
Low-CB		-0.012***					
		(0.004)					
Collective bargain			-0.007*	-0.018***			
			(0.004)	(0.006)			
Meet and confer			-0.001	-0.007			
			(0.006)	(0.006)			
Union density					-0.020**		
					(0.008)		
Union member						-0.008**	-0.005***
						(0.004)	(0.001)
Master's & above		0.01***	0.01**	0.01***	0.01***	0.01***	0.003**
		(0.003)	(0.003)	(0.003)	(0.004)	(0.003)	(0.001)
Observations	33,080	33,080	33,080	33,080	33,080	33,080	33,080
Adjusted R^2	0.006	0.011	0.010	0.009	0.010	0.010	0.013

Note: Errors are clustered within districts (presented in parentheses). $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$. The data source is the district-teacher matched SASS-TFS data for 2007-2009. Other covariates include gender, ethnicity, race, experience, experience^2, interaction between experience and gender and between experience^2 and gender, a dummy for secondary schools (grades 7-12), log(number of days in the school year), log(total student enrollment grades K-12), log (CWI), log(revenue), fraction of students eligible for free or reduced-price lunch programs, students' ethnicity and race, census regions, and urbanism of the districts that schools are located in. The instruments for CB are legality of CB and union density> 0.5. The instruments are both relevant and exogenous; the first stage F-statistic is 792.32, and the J-statistic is 1.509 with the p-value of 0.470.

Table A2: Estimates of the Effects of Teachers Unions on Voluntary Job Termination of Novice Teachers Whose Teaching Experience is Five Years or Less

Dependent Variable: Binary variable indicating if a teacher has left teaching career

	Panel A: 2011-2013 district-teacher matched data					Panel B: 2007-2009 district-teacher matched data				
VARIABLES	(1) OLS	(2) IV	(3) OLS	(4) OLS	(5) Dist. FE	(6) OLS	(7) IV	(8) OLS	(9) OLS	(10) Dist. FE
Collective bargain	-0.032***	-0.053***				-0.008	-0.035**			
	(0.012)	(0.013)				(0.009)	(0.014)			
Meet and confer	-0.018	-0.030***				0.005	-0.011			
	(0.013)	(0.009)				(0.012)	(0.013)			
Union density			-0.024**					-0.033**		
			(0.011)					(0.014)		
Union member				-0.014*	-0.006				-0.016**	-0.007*
				(0.007)	(0.005)				(0.007)	(0.004)
Observations	7,310	7,310	7,310	7,310	7,310	8,410	8,410	8,410	8,410	8,410
Adjusted R^2	0.018	0.017	0.013	0.013	0.013	0.020	0.018	0.021	0.020	0.013

Note: Errors are clustered within districts (presented in parentheses). $^{***}p < 0.01$,$^{**}p < 0.05$, $^{*}p < 0.1$. The data source is the district-teacher matched SASS-TFS data for 2011-2013 and for 2007-2009. Other covariates include gender experience^2, interaction between experience and gender and experience^2 and gender, a dummy for secondary school, log(number of days in the school year), log(total student enrollment grades K-12), log(CWI), log(revenue), fraction of students eligible for free or reduced-price lunch programs, students' ethnicity and race, census regions, and urbanism of the school districts that schools are located in. The instruments for CB are agency shop and union density$>$ 0.5. The instruments are both relevant and exogenous in both periods. For column (2), the first stage F-statistic is 94.41, and the J-statistic is 3.257 with the p-value of 0.071. For column (7), the first stage F-statistic is 264.80, and the J-statistic is 0.412 with the p-value of 0.521.

Table A3: Estimates of the Effects of Teachers Unions on Teacher Quality, 2007-2009

Dependent Variable: Binary variable for High Quality Teacher (HQT)

VARIABLES	(1) OLS	(2) OLS	(3) OLS	(4) IV	(5) OLS	(6) OLS	(7) Dist. FE
Log(base salary)	0.104***						
	(0.010)						
High-CB		0.011					
		(0.010)					
Med-CB		-0.009					
		(0.010)					
Low-CB		-0.021**					
		(0.009)					
Collective bargain			0.011	0.015			
			(0.009)	(0.013)			
Meet and confer			0.013	0.016			
			(0.011)	(0.012)			
Union density					0.028**		
					(0.014)		
Union member						0.023***	0.033***
						(0.007)	(0.005)
Observations	33,440	33,440	33,440	33,440	33,440	33,440	33,440
Adjusted R^2	0.018	0.023	0.023	0.023	0.022	0.023	0.059

Note: Errors are clustered within districts (presented in parentheses). $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$. The data source is district-teacher matched SASS-TFS data for 2007-2009. Other covariates include gender, ethnicity, race, experience, experience^2, interaction between experience and gender and between experience^2 and gender, a dummy for secondary schools (grades 7-12), education level, log (number of days in the school year), log(total student enrollment grades K-12), log(CWI), log(revenue), fraction of students eligible for free or reduced-price lunch programs, students' ethnicity and race, census regions, and urbanism of the districts that schools are located in. The instruments for CB are legality of CB and union density$>$ 0.5. The instruments are both relevant and exogenous; the first stage F-statistic is 472.93, and the J-statistic is 0.023 with the p-value of 0.897.

Table A4: Estimates of the Effects of Teachers Unions on High School Dropout Rate, 2003-2012 SASS Panel Data

Dependent Variable: High school dropout rate (in percent)

VARIABLES	(1) OLS	(2) OLS	(3) OLS	(4) IV	(5) OLS	(6) State FE
Log(base salary)	0.025					
	(0.515)					
High-CB		-1.085*				
		(0.560)				
Med-CB		-1.443***				
		(0.477)				
Low-CB		0.015				
		(0.352)				
Collective bargain			-0.859**	-1.812***		
			(0.395)	(0.424)		
Meet and confer			-0.637*	-1.237***		
			(0.388)	(0.347)		
Union density					-0.810*	-0.214
					(0.458)	(0.192)
Year FE	YES	YES	YES	YES	YES	YES
Observations	3,380	3,360	3,360	3,360	3,380	3,380
Adjusted R^2	0.342	0.378	0.374	0.369	0.342	0.418

Note: Errors are clustered within states (presented in parentheses).$^{***}p < 0.01$,$^{**}p < 0.05$,$^{*}p < 0.1$. The data source is the district-teacher matched 2003-2012 SASS panel data. Other covariates include race and ethnicity of teachers and of students in percent, log(total student enrollment grades K-12), fraction of students eligible for free or reduced-price lunch programs, log(CWI), number of school days, log(revenue), census regions, and urbanism of the districts that schools are located in. Columns (1), (5), and (6) have fewer observations than others because base salary and union density of each district is computed using the teacher-level SASS, and some teachers do not report their union status. The instruments for CB are mandatory CB and union density$>$ 0.5. The instruments are both relevant and exogenous; the first stage F-statistic is 116.68, and the J-statistic is 0.610 with the p-value of 0.435.

Table A5: The Effect of Legal Changes Limiting Collective Bargaining Rights of Public Sector Workers on Wages of Private Sector Workers, 2004-2012

	Before legal changes	After legal changes	Treatment effect= After−Before
Dependent Variable: Log(Real Hourly Wage)			
Treatment group	2.732	2.736	0.004
	(0.004)	(0.010)	(0.003)
Control group	2.792	2.796	0.004
	(0.001)	(0.003)	(0.011)
Difference (Treatment−Control)	-0.060	-0.60	0.000
	(0.004)	(0.011)	(0.008)

Note: Clustered standard errors are presented in parentheses. $***p < 0.01$. The data source is the Current Population Survey March 2004, 2008, and 2012 data. The treatment group includes WI, ID, IN, and TN. The control group includes other states in the High-CB and Med-CB groups that mandate CB.

Appendix II Discussion of union effects on dropout rates

In contrast to the negative union effects on dropout rates in this study, Hoxby (1996) finds that unionism raises dropout rates for 1970, 1980, and 1990. Lovenheim (2009) shows no union effects on dropout rates for the same period. I offer two plausible explanations for the inconsistency between these studies. First, it may be partly due to different measures of unionism used in each study. Lovenheim measures unionism with union certification information − whether teachers have an agent certified by the state to engage in CB. Since it focuses on three Midwestern states − Iowa, Indiana, and Minnesota − which have compulsory CB laws during his study period, certified union representation will almost certainly yield bargaining contracts and never-unionized districts are rare. Moreover, unions can have MC agreements as well as CB contracts with districts. My calculation using the 2003-2013 SASS panel data for the three states shows that 97 percent of districts have an agreement with unions or other teacher associations (85 percent of districts have CB and 12 percent have MC), so union certification data are likely to give little variation in unionism in those three states. Hoxby covers districts in all US states, but she measures unionism with a strict definition (CB and at least 50 percent union density). According to my calculation using the SASS panel data, over 20 percent of districts that have less than 50 percent union density reach CB agreements with unions. Her strict measurement of unionism misclassifies these bargaining districts as non-unionized.

Another reason for inconsistency in results might be due to the time periods in which each study focuses. For example, in Iowa in 1977, about 50 percent of districts are considered

unionized in Lovenheim's data, but over 90 percent of districts have CB in 2007. Further, those three states were experiencing a dramatic increase in teachers' unionization during the time period covered by his data, so his union measure fails to capture the full strength of unionism beyond the majority rule of teachers' votes for union certification. Therefore, his measure of unionism is subject to systematic measurement errors, and the estimate of the union effects, aside from the external validity issue, is likely to be underestimated. In this case, union density would serve as a better metric to measure the strength of teachers unions. If I follow Hoxby's strict definition of unionism, about 60 percent of school districts are considered unionized in 2003, which is a substantially higher number compared to 13 percent in 1970. During the same period, the dropout rate in public schools has fallen considerably and currently is less than 4 percent in 2003, while it was 13 percent in 1970.

I employ similar setups from Lovenheim and Hoxby to re-estimate the union effects on dropout rates using the SASS panel data and report the results in Table B1. Panel A focuses

Table B1: A Comparison of Union Effects on the Dropout Rate with Lovenheim (2009) and Hoxby (1996)

Dependent Variable: High school dropout rate (in percent), 2003-2012

	Panel A: Lovenheim (IA, IN, MN)				Panel B: Hoxby (All)	
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	OLS	State FE	OLS	State FE	OLS	IV
Collective bargain	-0.231	-0.387				
	(0.268)	(0.253)				
Union density			-0.948**	-0.961**		
			(0.374)	(0.470)		
Unionization (CB					-0.242	-0.410
and density>0.5)					(0.390)	(0.874)
Year FE	YES	YES	YES	YES	YES	YES
Observations	410	410	360	360	6,460	6,460
Adj. R-squared	0.526	0.537	0.544	0.553	0.247	0.246

Note: Errors are clustered within states (presented in parentheses).***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. The data source is the district-teacher matched 2003-2012 SASS panel data. I focus on Iowa, Indiana, and Minnesota to follow Lovenheim in Panel A, and I use a strict definition of unionism (CB districts with at least 50 percent union density) to follow Hoxby in Panel B. Other covariates include race and ethnicity of teachers and of students in percent, log(total student enrollment grades K-12), fraction of students eligible for free or reduced-price lunch programs, log(CWI), log(number of school days), log(revenue), census regions, and urbanism of the districts that schools are located in. Columns (3) and (4) have fewer observations than columns (1) and (2) because union density of each district is computed using the teacher-level SASS and some teachers do not report their union status. The instruments for CB in column (6) are agency shop and legality of CB. The instruments are both relevant and exogenous; the first stage F-statistic is 211.65, and the J-statistic is 0.018 with the p-value of 0.893.

on the three states following Lovenheim. In column (1), the effect of CB on the dropout rate is statistically insignificantly different from zero, and adding the state fixed effects in column (2) does not change the pattern. If, however, I use union density to measure unionism in columns (3) and (4), the estimated union effects on the dropout rate is significantly negative. In Panel B, I use Hoxby's strict definition of unionism, which fails to produce statistically significant effects on the dropout rate in both the OLS and IV estimation. The sign of the union effects on dropout rates, however, is negative in both panels. This suggests that the attenuation bias due to measurement errors in both studies cannot entirely explain the inconsistency of results, leaving the difference in the time periods covered in each study also responsible.

For the last three decades, teachers' unionization has risen while dropout rates have fallen. Although I cannot examine the long-term relationship between the two, my model suggests that districts with strong unionism create more favorable labor market conditions for teachers, raising average teacher quality (or prevent it from falling). Moreover, a cross-sectional analysis separately for the 2003-2004 SASS and 2007-2008 SASS show that the effect of teachers unions on the dropout rate is smaller in those years than in 2011-2012. This might be partly due to districts' different reactions to the recent financial crisis. During the recession, unionized districts might have had stronger resilience (and a better response) to economic shock. For instance, districts with strong unionism might be able to retain more high-quality teachers, as fewer outside options become available. When districts have fewer resources, they may need to let go more low-quality teachers during the probationary period, granting tenure to only a few highly-selected teachers. A full discussion of this issue is beyond the scope of this study, and further research is warranted to identify the long-run relationship between unions and educational outcomes, as well as the causal effect of financial crisis on teacher turnover.