Spatial Explanations for Deferred Teacher Compensation: Unions and Competition for Teachers

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The COVID-19 pandemic has exacerbated concerns about public sector worker shortages. Discussions about education policy focus heavily on the supply of teachers. This reflects a widespread understanding that teacher quality is an important determinant of student outcomes (Chetty, Friedman, and Rockoff 2014; Goldhaber 2016; Kraft 2019). It also reflects widespread concerns that the quantity of available teachers is or will soon be insufficient – at least in some school and in some positions – due to a combination of weak recruitment and high attrition (Camp, Zamarro, and McGee 2022; Cowan et al. 2016; Goldhaber and Theobald 2023; Nguyen, Lam, & Bruno 2024; Sutcher, Darling-Hammond, and Carver-Thomas 2016).

Concerns about the supply of available teachers have often motivated attention to teacher compensation as an important lever for teacher recruitment and retention (Davila 2024; Han 2021; Hendricks 2014; 2015). Yet over and above questions of the overall level of teacher compensation, many researchers and commentators have pointed out that how teachers are compensated often appears not to be strategic. For example, observers have often worried that teacher compensation is insufficiently differentiated based on worker quality. I focus on another aspect of teacher compensation that is often considered un-strategic: that it is heavily deferred to relatively late in teachers' careers, or "backloaded", for example in the form of retirement benefits or later-career salary increments (Bruno 2019, 2021; Fitzpatrick 2015; Vigdor 2008).

Previous Literature

While an extensive literature examines teacher compensation, this work typically focuses on salary levels (e.g., Akiba et al., 2012; Figlio, 1997; Hanushek & Rivkin, 2007; Imazeki, 2005) or the differentiation of compensation between teachers, for example based on performance (Pham, Nguyen, and Springer 2021). Comparatively few studies consider the shape of teacher salary schedules or the extent to which they are frontloaded.

However, extant work is generally in agreement on two questions. First, teacher salary schedules are often backloaded, in some cases significantly (Grissom and Strunk 2012; Lankford and Wyckoff 1997; Monk and Jacobson 1985; Vigdor 2008). Second, both theory and evidence suggest that frontloaded salary schedules allow schools to attract and retain teachers more effectively (Grissom and Strunk 2012; Hendricks 2014; 2015; Murnane et al. 1991).

There are three predominant theoretical explanations for why, if frontloaded teacher salary schedules are more efficient or effective, backloaded salary schedules remain common. I consider the research on each of those explanations in turn.

Imperfect Information About Teachers

One potential explanation for the backloaded nature of teacher compensation, including salaries, notes that it is not uncommon for workers generally to be compensated in a backloaded fashion (Hek and Vuuren 2011; Prendergast 1999). This fact has motivated the development of theories that justify backloaded compensation as a rational response by employers to imperfect information about workers.

If it is difficult to discern worker quality, that would give employers a reason to defer compensation even if frontloaded compensation would make the job more attractive to workers. For example, if workers have better information about their potential productivity or commitment to the job than is available to employers, then deferring compensation until later in workers' careers may tend to select for workers who have reason to believe that they will continue in the job until that compensation can be obtained (Salop and Salop 1976). Deferred compensation may also select for workers with a higher propensity to save, reflecting an underlying conscientiousness that is difficult for employers to observe (Ippolito 2002).

Similarly, once workers are hired compensation deferred into the future can serve as an incentive to workers who risk losing that compensation if caught shirking (Lazear 1981; Prendergast 1999). This would help to explain why frontloaded compensation is more prevalent in occupations where performance is relatively easy to observe, such as sales, and unnoticed shirking therefore less of a concern (Kotlikoff and Gokhale 1992; Prendergast 1999).

The possibility that backloaded teacher compensation is driven by administrators' imperfect information about teachers has gained less traction among researchers than the theories discussed below. In part, this is because there are empirical reasons to doubt that these dynamics are salient in the case of public school teachers specifically. For example, a growing body of research suggests that administrators can, in fact, discern useful information about teacher quality even prior to employment, during the teacher hiring process (Bruno 2024a; Goldhaber, Grout, and Huntington-Klein 2017; Jacob et al. 2018). Moreover, even if school administrators have limited information about teacher quality, it is not clear that deferred compensation would be an effective incentive to alter teacher behavior. For example, public school teachers appear to value pension benefits far below the cost of providing them (Fitzpatrick 2015), suggesting that they are not highly motivated by this type of deferred compensation. Moreover, backloaded salary schedules are not consistently associated with higher student achievement (Grissom and Strunk 2012) or lower vacancy rates (Goldhaber et al. 2018), as would be expected if deferred compensation was selecting for more capable or committed teachers. Additionally, teachers enjoy considerable job protections that make even observed shirking difficult to punish, rendering deferred compensation unnecessary as an incentive (Ballou and Podgursky 2002).

It is therefore not surprising that studies testing whether school districts defer compensation as a substitute for monitoring have not found evidence for that hypothesis. Heutel

(2009) uses the administrator-to-teacher ratio as a proxy for a districts' ability to catch teacher shirking but finds that it is unrelated to the extent to which districts' teacher salaries are deferred as measured by the ratios of tenth- or twentieth-year salaries to starting salary. Bruno (2024b) extends this approach with more detailed salary and compensation information, longitudinal data on school districts, and information on actual teacher monitoring (i.e., evaluation) practices derived from collective bargaining agreements, but again finds no evidence to support a relationship between information about teachers and compensation deferral.

Competition for Teachers in the Labor Market

Existing research offers two theories for why frontloaded salaries are attractive to teachers and will thus allow districts to better compete for teachers in the labor market. Both arguments can claim some empirical support, though the empirical literature is limited.

First, as with many workers, the productivity returns to experience for teachers appear to be largest during the early years of teachers' careers (Clotfelter et al. 2008; Ladd and Sorensen 2016; Papay and Kraft 2015; Rockoff 2004; Wiswall 2013). Workers who are more productive are not only more valuable to their employers, but more valuable to other potential employers; if a teachers' compensation does not keep pace with their productivity, they may leave for an employer (e.g., another school district) offering a higher wage (Han 2021). Districts should therefore offer a wage profile that is steeply increasing in experience so as not to lose its newer teachers as they become more effective, and can offer smaller (if any) raises for more experienced teachers (Ballou and Podgursky 2002; Lankford and Wyckoff 1997).

Second, workers later in their careers may be less sensitive to changes in wages than their less experienced counterparts. Prospective teachers are often uncommitted to a particular profession, the productivity of later-career teachers may be more job-specific as their tenure increases, and many districts pay teachers based on their in-district experience and so will not pay veterans for the entirety of their experience acquired elsewhere. An additional increase in salary for a relatively novice teacher should therefore have greater force as an incentive than an increase of the same magnitude for a veteran (Lankford and Wyckoff 1997).

There is some evidence that districts establish salary schedules that are sensitive to competition for teacher labor and teachers' potential labor market opportunities, though the results are by no means unambiguous. For example, Rose and Sengupta (2007) find in California that districts in regions with higher non-teacher wages or lower rates of new teacher credentialing offer higher salaries to teachers. These relationships are particularly evident when considering the first 10 steps of the salary schedule compared to the second 10 steps. This is consistent with the theoretical rationales for frontloading discussed above, as a more competitive market for teacher labor will tend to make both novice teachers' skill acquisition and novices' relatively greater sensitivity to compensation more salient.

Of particular interest for present purposes are several studies that assess the extent to which nearby districts affect one another's salary schedules using spatial econometric methods (Greenbaum 2002; Millimet and Rangaprasad 2007; Wagner and Porter 2000; Winters 2011). These studies differ somewhat in how they operationalize proximity between districts, but consistently find spatial salary spillovers. That is, districts tend to offer higher salaries when nearby districts offer higher salaries, and this is true for average teacher salaries (Millimet and Rangaprasad 2007) and salaries for both novices (Wagner and Porter 2000; Winters 2011) and more veteran teachers (Greenbaum 2002; Winters 2011).

Only Winters (2011) considers salary spillovers for both more and less experienced teachers. He finds that these spillovers are roughly 27% larger in magnitude for starting salaries than for salaries for 20-year veterans. In particular, he finds that a one-percent increase in the average teacher salary in nearby districts increases salaries in a district by 0.66% for novices but only 0.52% for their more experienced counterparts. These results are again consistent with districts not only competing with one another for teachers on the basis of salary but competing more aggressively for less-experienced teachers.

However, these studies are analyses of cross-sectional data, making causal inference difficult. It is therefore significant that the only longitudinal study of competition as a determinant of salary schedule structure arrives at a contrary conclusion. Ballou and Podgursky (2002) use data on more than 1,400 districts nationwide observed three times between the 1987-1988 and 1993-1994 school years. They find no relationship between staffing difficulties in the base year – as measured by districts' teacher certification or vacancy rates – and starting salaries for new teachers in subsequent years. However, they do find that districts with more unfilled positions subsequently made larger increases than other districts in salaries for teachers with 20 years of experience and a master's degree. This is suggestive of, if anything, greater backloading in districts with greater staffing difficulties, which is difficult to explain in terms of competition for teachers in the labor market. The extent to which school districts frontload teacher compensation to compete for teachers is thus far from clear.

Union Influence

An alternative theory of deferred compensation, and perhaps the theory most frequently emphasized in the literature, is that backloading of compensation is not useful for schools but rather a mechanism by which teachers' unions extract rents from districts for their more experienced members. On this account, when salaries are collectively bargained by teachers' unions and district officials, the outcome will tend to reflect the interests of the union because district leaders have few incentives to bargain for more efficient contracts. And, if more veteran teachers are more influential in the union, for example because novices have not been socialized into the union (Pogodzinski 2012), the result will be backloaded compensation structures favoring veteran teachers (Anzia and Moe 2015; Hek and Vuuren 2011; Lankford and Wyckoff 1997; Moe 2006; Monk and Jacobson 1985). But this is by no means the only theory about how unions may influence the shape of the salary schedule. Another possibility is that unions will advocate for more heavily frontloaded schedules because this will allow members to earn the highest possible salaries more quickly and for a longer period (Ballou and Podgursky 2002).

Both theories find some support in the literature. On the one hand, Grissom and Strunk (2012) compare salary schedules in districts that collectively bargain contracts to those that do not. Consistent with the union influence hypothesis, they find significantly more backloading in jurisdictions with greater involvement in contract negotiations. Similarly, Winters (2011) finds that collective bargaining activity is associated with higher teacher salaries, but more so for veterans (i.e., those with 20 years of experience and a master's degree) than for starting teachers with only a bachelor's degree. This is again consistent with unions prioritizing salary increase for more experienced teachers over those of newer teachers.

On the other hand, Gustman and Segal (1977) compare a cross-section of unionized and non-unionized districts and find that not only are maximum salaries higher in unionized districts' salary schedules, but that they are obtained after fewer steps. These steeper initial wage-experience profiles are consistent with unions advocating frontloaded compensation because this involves few trade-offs with later-career salary levels in practice. West and Mykerezi (2011) find more recently in two separate national samples of districts that collective bargaining is associated with teachers receiving larger annual raises early in their careers and reaching maximum salary levels more rapidly. This is again consistent with the frontloading theory of union behavior.

The literature on unions' influence on salary schedule frontloading is thus mixed, both theoretically and empirically. This may be because existing work typically employs crude proxies for union influence (typically, a categorical indicator of collective bargaining status) and lacks the ability to account for major sources of endogeneity.[1] Finally, the possibility that teachers' unions influence teacher salaries also complicates interpretation of the spatial models discussed earlier, which suggest some degree of competitive frontloading of salary schedules. To the extent that union influence is spatially correlated due to pattern bargaining, salary correlations between nearby districts may reflect shared union influences rather than competitive dynamics (Goldhaber, Lavery, and Theobald 2014; Greenbaum 2002). This motivates aspects of my empirical approach, described in greater detail below, by which I attempt to disentangle union influences from labor market competition.

Research Questions

Given the ambiguities in the theoretical and empirical literature discussed above, my two research questions ask why school districts frontload their salary schedules to different degrees. First, *Is the shape of teacher salary schedules a response to competition for teachers?* If school districts are sensitive to competitive pressures in the teacher labor market, then a given districts' teacher salaries should be positively correlated with the salaries of teachers in nearby districts. Given the relatively greater sensitivity of more novice teachers to compensation, these relationships should be largest in magnitude for less experienced teachers. Second, *Is the shape*

[1] Mixed empirical results on the influence of teachers' unions on salary schedule frontloading could be reconciled by models that allow union influence to be moderated by local forces. Studies applying "median-voter" models have found that whether union influence leads to more backloaded compensation depends on the average experience of union members (Babcock and Engberg 1999; Bruno 2024b). This suggests unions alter their bargaining priorities to be responsive to member preferences (e.g., because a more novice membership would benefit less from a backloaded salary schedule).

of the salary schedule the result of teachers' union influence? If unions are impacting the structure of compensation in districts, then local teachers' unions under the influence of the same supra-local union organizations should have similarly frontloaded salary schedules.

Data

Data on California school district salary schedules come from "Salary and Benefits Schedule for the Certificated Bargaining Unit" surveys – commonly known as "J-90" surveys – submitted by districts to the California Department of Education (CDE) each year. These surveys ask districts about the composition of their teacher salary schedules, including the salary offered at each step (i.e., experience level) of each lane of the schedule (i.e., for each level of education). This is considerably more detail about each salary schedule than is available in similar data sets used in previous work, which typically relies on information about compensation at just a few step-and-lane combinations. Additionally, districts identify on the J-90 the salary schedule lane occupied teachers with a BA and 60 additional units of education (BA+60). I focus on salaries in this lane specifically in my analyses below, allowing me to compare salaries for similarly educated and experienced teachers across districts and over time despite differences in salary schedule lane structure. These surveys also include the number of service days for returning teachers. I adjust all salary amounts for inflation using the Consumer Price Index, accounting for the fact that academic years span multiple calendar years (Shores and Candelaria 2020).

The CDE releases enrollment and student demographic data at the school level. I aggregate these to the district level after excluding charter schools, which are generally not covered by district CBAs. I take school district boundary shapefiles from the National Historical Geographic Information System (Manson et al. 2018). One concern when using the spatial autoregressive models (described below) is that the characteristics of districts' neighbors (and thus the spatial lag terms) could change over time solely because of different neighbors being observed in different years. I therefore restrict my sample to school districts observed with complete information in every year from 2009-2010 through 2018-2019. This creates a strongly balanced panel of 498 school districts. Summary statistics are presented in Table 1.

Empirical Strategy

While several studies, discussed above, consider spatial correlations in district salaries, they are largely limited to cross-sectional analyses. Additionally, spatial relationships between salaries in nearby districts are difficult to interpret because districts that are geographically proximal are likely to be compositionally similar, to learn from one another, and so on (Goldhaber, Lavery, and Theobald 2014). I therefore take an approach that estimates spatial relationships between districts that attempts to disentangle two potential causes of salary schedule spillovers that correspond to my two research questions: competition for teachers and union influence. Like Goldhaber, Lavery, and Theobald (2014), but extended to the panel data context, I estimate the following spatial lag model:

$$\ln\left(sal_{dt}^{s}\right) = \boldsymbol{\rho}_1 \sum_{j\neq d} W_{dj}^{dist} \ln\left(sal_{jt-1}^{s}\right) + \boldsymbol{\rho}_2 \sum_{j\neq d} W_{dj}^{sc} \ln\left(sal_{jt}^{s}\right) + \boldsymbol{D}_{dt-1}\boldsymbol{\Omega} + \delta_d + \gamma_t + \varepsilon_{dt}$$

(1)

The outcome of this model is the natural log of the salary at step *s* of the salary schedule for teachers with a BA+60 in district *d* in year *t*. Results are very similar if I do not log salaries. Model 1 includes two separate spatial lag terms – my predictors of interest – to distinguish the unique contributions of two distinct types of spillover that plausibly reflect either competition for teachers in the labor market or union influence. Each W is an element from a weighting matrix $\boldsymbol{W}$ where element W_{dj} represents the proximity (however defined) between districts *d* and *j*. By convention, W_{dd} is equal to zero since each district is assumed to have no spillover effect on itself.

To evaluate competitive salary spillovers, I look for spillovers related to physical proximity between districts. How to operationalize physical proximity is not obvious. In my primary specification, $\boldsymbol{W}^{dist}$ is a row-normalized first-order contiguity matrix. That is, each element W_{dj}^{dist} is first set equal to one if districts *d* and *j* are contiguous and is otherwise equal to zero. Each element is then divided by the sum of its respective row so that the weights of all other districts for district *d* sum to one. In addition to facilitating model estimation in some cases (Kelejian and Prucha 2010), row normalization has two substantive advantages. First, it equalizes the effect of neighboring districts on each individual district (i.e., districts are not assumed to be more heavily influenced by neighbor effects when they have more neighboring districts). Second it has the intuitive and interpretable consequence that $\sum_{j \neq d} W_{dj}^{dist} \ln\left(sal_{jt-1}^{s}\right)$ for each district is simply the average of logged salaries of its neighbors.

$\boldsymbol{W}^{dist}$ thus assumes that districts have more influence over one another when they are physically proximal, as would be the case if they are competing with one another for teachers. In this case, neighboring districts' salaries are lagged by one year since in general a district's salary schedule in year *t* will have been negotiated no later than year *t*-1. Given evidence that both teachers and administrators value proximity in the teacher labor market (Boyd et al. 2005; Killeen and Loeb 2022), this is a plausible model of the underlying spatial dynamics.[2]

[2] Simulation studies suggest that first-order contiguity matrices outperform other weight matrices in spatial lag models using geographic units with irregular boundaries and row-normalized weight matrices (Stakhovych and Bijmolt 2009). In an alternative specification similar to previous work (Goldhaber, Lavery, and Theobald 2014; Winters 2011) I specify $\boldsymbol{W}^{dist}$ as an inverse distance matrix. This produces mostly similar results to using a first-order contiguity matrix, albeit smaller estimated geographic spillovers (Appendix Figure A1). This is consistent with other work finding that matrices with greater connectivity between units can be underpowered and result in estimates that are biased downward (Anselin and Rey 1991; Beer and Riedl 2012; Farber, Páez, and Volz 2009; Smith 2009).

An additional consideration is that a single-year time lag may not fully capture competitive salary responses because those responses would require renegotiation of the CBA. I am not overly concerned

Like Goldhaber et al. (2014), I also look for *institutional* spillovers between districts served by the same union service center of the California Teachers Association (CTA). These service centers are regional and while they are not policymaking bodies they provide coordination functions within the CTA. This includes serving as liaisons to communicate information in both directions between the CTA and local district affiliates. Additionally, service centers support and coordinate activity between local affiliates, such as bargaining, political engagement, and professional development. Bargaining objectives, tactics, and so on may therefore disseminate more easily between districts within a service center than across service centers. The CTA maintains 25 K-12 service centers that vary widely in size. This variation is difficult to quantify given California's complicated local education agency governing structure and geography, but for perspective the mean or median service center serves approximately 30-40 districts, but a few serve fewer than two dozen or over 100 districts. Similarly, while the median service center covers a geographic area of about 4,300 square miles, service centers range in size from less than approximately 200 to more than 30,000 square miles.

I operationalize these service center relationships with weighting matrix $\boldsymbol{W^{sc}}$, where W_{dj}^{sc} = 1 if districts *d* and *j* are in the same CTA service center, and W_{dj}^{sc} = 0 otherwise.[3] Thus, $\boldsymbol{W^{sc}}$

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about this because to the extent that CBAs constrain competition that is as much an explanation of my results as it is a source of bias, though it is useful to remember that competitive effects may vary over time or under different policy regimes. In any case, California law requires that districts renegotiate their CBAs at least every three years. Moreover, a district and its teachers' union could reopen the CBA if they so choose by mutual consent. Indeed, in a data set used in other work exploring California district CBAs in more detail I observe that 70% include explicit provisions indicating that salary specifically is an issue that can be reopened over the life of the agreement, far more often than any other non-compensation issue. Thus, it is likely that at any given moment most districts in California are or could be actively bargaining their teacher salary schedules.

[3] 2.5% of California districts (2.4% in my sample) are represented by the California Federation of Teachers (CFT) rather than the CTA. I treat these as their own service center. I drop the Los Angeles Unified School District, which effectively represents its own CTA service center while also maintaining affiliation with the CFT. Though I am not aware of systematic evidence of their prevalence, regional union service centers are common among teachers' unions in the United States. For example, the NEA

assumes that unions can have influences on districts that diffuse through social networks operating within these service centers, regardless of physical distance between districts.

Previous work identifies several school district characteristics that are likely to be correlated with or determinative of teacher salaries despite not reflecting to a substantial degree either competition for teachers or union influence. I therefore include as controls in ***D*** the shares of students who are Black, who are Hispanic, or who are eligible for free or reduced-price lunch; the natural log of enrollment, an indicator of whether the district has declining enrollment year-over-year, and the number of service days for returning teachers (Grissom and Strunk 2012; Winters 2011). Because salaries in year *t* will typically have been negotiated prior to year *t* (along with work days for teachers), all other control variables are measured in *t*-1. As noted previously, an important limitation in previous work is the cross-sectional nature of available data. As noted above, a potential concern about studies of inter-district effects is that they could produce estimates biased by unobserved differences between districts that are both spatially correlated and determinative of salaries. For instance, districts in different regions may have different political climates affecting collective bargaining or local taxes or may have different costs of living. I exploit the panel nature of my data to control for unobserved mean differences between districts by including district fixed effects (δ), and I include year fixed effects (γ) to account for year-to-year factors with a common influence on all districts.[4] ε is an error term and I

operates similar systems in Washington State (Goldhaber et al. 2014), and NEA websites indicate the presence of similar systems in states of as varying sizes as Illinois (IEA n.d.) and Delaware (DSEA n.d.).

[4] I do not adjust salaries for comparable wages of the non-teaching workforce, as is commonly done in studies of teacher compensation. Because comparable wages are typically estimated at a regional (e.g., county) level, such adjustments would introduce a mechanical correlation between the salaries of physically proximal districts. That correlation could be dominated by measurement error in comparable wage estimates after accounting for district fixed effects or reflect primarily between-sector (rather than between-district) competitive forces. District fixed effects will account for differences in labor costs that are time-invariant, but I cannot rule out bias from geographically correlated, time-varying labor costs.

cluster standard errors at the district level. Because spatial lag models place the dependent variable on the right-hand side of the model, estimates from model 1 of $\rho1$ and $\rho2$ could suffer from simultaneity bias. This will tend to bias estimates toward finding spatial interdependence Elhorst (2014). I therefore estimate model 1 via maximum likelihood (Lee and Yu 2010).

Results

RQ1: Competition for Teachers

Results from my primary specification are shown in Figure 1. Each coefficient represents the estimated relationship between a district's own (logged) salary at a step of the salary schedule and the spatially- and temporally-lagged salaries of contiguous districts (on the left) or the spatially-lagged salaries of other districts in the same union service center (on the right). Black markers come from models in which only one spatial lag term is included. Gray markers come from models where both are included. In all cases, including the second spatial lag term reduces the magnitude of the estimated spillovers associated with the other lag term. This illustrates the importance of distinguishing different potential reasons why spatial relationships might be observed: proximity along one dimension will often indicate other, potentially unobserved similarities. All subplots in Figure 1 have the same axes to facilitate comparison.

The first row of Figure 1 presents results from models estimated using all districts in my sample, regardless of grade level served. The black markers in the top left panel indicate that when adjacent districts' salaries increase by one percent and within-service center relationships are not accounted for, a district's own salary increases by approximately .20-.40%. (Because I log all salaries, I interpret coefficients as approximate elasticities.) These are smaller spillovers than found by Winters (2011), particularly for novice teachers, which could reflect differences in context, spatial weight specification, or the importance of district-level heterogeneity. Moreover, estimates shrink further when accounting for within-service-center relationships (the gray markers), suggesting elasticities of approximately 0.15 to 0.25.[5]

While these results are consistent with competiation, such effects appear modest and smaller than estimated in previous work. And like Winters (2011), I find that the spillovers are larger in magnitude at earlier steps of the salary schedule than at the latest steps. For example, a one percent increase in adjacent districts' salaries predicts an increase in a district's own salaries of about .18% at step 1, about 22% larger than what I estimate at step 30. However, this difference is substantively small. For context, for the mean district (see Table 1) a one percent increase in step 1 salaries represents about $554 and these results imply a spillover from such a raise in adjacent districts of about $97. At step 30 the analogous figures are $898 and $130. This provides little evidence that districts are particularly aggressive about competing for novice teachers based on salary. Similarly, the largest spillovers I estimate are not for novices, but for mid-career teachers (i.e., approximately steps 11-18).

One possible explanation for these small estimated geographic spillovers is that they are attenuated by the inclusion of districts that are not competing with one another for teachers because they serve different grade levels. Because elementary teachers typically are not certified to teach single-subject secondary courses (and vice versa), the labor markets for elementary and secondary teachers are largely segmented and often have different dynamics (e.g., shortage rates;

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[5] Given the many differences between Winters' (2011) data and my own I cannot fully evaluate why our estimates differ. Still, I present evidence about the importance of some modeling choices in Appendix Figure A2. Accounting for district fixed effects substantially explains why my results are smaller in magnitude, though the choice of weight matrix and accounting for service centers also appear to matter. Also, one might wonder whether salary relationships between contiguous districts itself reflects union influence because teacher contracts may require districts to conduct studies of nearby districts to maintain salary parity. However, only about 6% of California districts have salary parity study provisions of any kind in their teacher contracts (Strunk 2012). More generally, my results should be interpreted as relationships that exist under status quo teacher contracts, not as reflecting the relationships that might exist under different contracts or that might be preferred by either administrators or teachers' unions.

Bruno 2023). I assess this possibility by isolating either districts serving largely elementary grade levels (i.e., elementary/K-8 or unified/K-12 districts, removing high school/9-12 districts) or districts serving substantially secondary grade levels (i.e., excluding elementary/K-8 districts and retaining only unified/K-12 and high school/9-12) districts. Estimates from these subsamples are presented in the second and third rows of Figure 1, respectively.

If my results are attenuated by segmentation between elementary and secondary teacher labor markets, they should grow in magnitude when focusing only on districts that are more likely hiring from the same pool of teachers. I find little evidence that this is the case. Estimated spillovers are often slightly larger for secondary-serving districts than they are for elementary-serving districts. This is consistent with tighter secondary teacher labor markets generating more competitive pressure between employers. However, these differences are small and, in many cases, both subsample estimates are smaller than what I observe in my pooled sample.[6]

RQ2: Teachers' Union Influence

The right-side panels of Figure 1 present results for spillovers between districts in the same union service center, analogously to the results for geographic spillovers. As with the previous research question, accounting for geographic spillovers reduces the magnitude of estimated service center spillovers. This is again not entirely surprising, since union service centers are to a substantial degree geographically defined.

[6] Another potential explanation for small estimated geographic spillovers is that competition could be limited by limits on the amount of experience that teachers can be credited for when they are recruited from other districts. This is unlikely to be a major factor because my estimates are small even at the lowest steps of the salary schedule, where such experience limits are usually not binding (Appendix Figure A3). However, these limits may help to explain why my estimates are somewhat smaller at higher steps since districts are more likely to prevent teachers from entering at higher steps of the salary schedule, making salary competition less salient for veterans. I do also find evidence of spillovers in maximum creditable experience between geographically proximal districts, suggestive of districts competing on the basis of creditable outside experience (Appendix Table A1). Results are similar if I include LAUSD (Appendix Figure A4).

In contrast with the geographic spillovers, however, the service center spillovers generally shrink less in proportional terms and remain quite large even after accounting for spillovers between physically proximal districts. In my pooled sample (the top right panel), and accounting for proximity-based spillovers, a 1% increase in other district salaries in a given service center predicts an increase in a district's own salary of anywhere from 0.25%-0.54%, depending on the salary schedule step. This is consistent with a substantial role for union influence in collective bargaining over compensation, mediated by the service center structure.

The fact that the estimated service center spillovers increase at higher steps of the salary schedule is also plausibly consistent with the mechanisms involving teachers' unions. Veteran teachers are often disproportionately influential in teachers' unions (e.g., due to low levels of union socialization among novices [Pogodzinski 2012]), and so pattern bargaining over salary within a service center may be more efficient at steps of the schedule occupied by more veteran teachers. Conversely, my estimated spillovers drop off precipitously at the bottom of the salary schedule: the within-service center elasticity I estimate at the first step of the salary schedule is only 0.25. That's less than half of the magnitude I estimate at the top half of the experience distribution and about one-third less than what I estimate even at the second step of the schedule. This is consistent with what would be expected if union influences transmit particularly inefficiently at the very bottom of the salary schedule. This could arise, for example, because starting salaries, almost by definition, affect only individuals who are not already in the union.

These patterns are largely similar when considering only districts serving elementary grades, as shown in the middle panel of the right side of Figure 1. When considering only high school-serving districts (the bottom right panel) service center spillovers are attenuated, particularly at higher steps of the schedule. For instance, at the 30th step of the salary schedule, a

1% increase in other-district salaries in the service center predicts an increase in a district's own salary at that step of about 0.54% when pooling all districts and after accounting for geographic spillovers. The estimate for elementary-serving districts is only slightly smaller (0.51%), while for high school-serving districts the estimate falls to 0.33%. Estimates for high school-serving districts remain non-trivial in magnitude, consistent with a role for union influence in these districts. However, the fact that service center spillovers do not grow at higher steps of the salary schedule in high school-serving districts is suggestive of different union dynamics.

Discussion

Concerns about the teacher supply have often focused on teacher compensation. While much of this attention focuses on overall or average levels of compensation, researchers and other stakeholders have also often raised concerns about whether teacher compensation is too heavily backloaded to effectively recruit and retain novice teachers into the profession. However, theoretical and empirical evidence to date has provided only conflicting and inconclusive accounts of why teacher compensation is – or should be expected to be – relatively backloaded.

I test two of the most common theories using detailed and longitudinal teacher salary data from California school districts and spatial autoregressive models. I find little evidence that school districts substantially frontload teacher compensation due to competitive pressures. However, I find evidence consistent with a substantial role for union influence. In particular, I find substantial salary correlations within regional union service centers. These correlations are generally larger for more veteran teachers, consistent with theoretical predictions, and are largely robust to controlling for geographic correlations with other nearby districts.

These results extend previous work in several ways as my data and empirical approach allow me to begin disentangling geographic and institutional relationships, to control for district-level heterogeneity that may have biased estimates in prior studies, and to paint a more detailed portrait of spatial relationships across the entire teacher experience distribution. At the same time, though I control for some time-varying district characteristics, I cannot rule out bias from other time-varying factors correlated with my spatial factors of interest.

Taken as a whole, my results suggest that even if school districts are somewhat sensitive to their neighbors' salaries, they do not necessarily respond to those salaries in optimally strategic ways. In particular, school districts may be insufficiently sensitive to competition for novice teachers relative to competition for veterans; the former are likely to be more sensitive to salary considerations, but geographic salary spillovers are approximately the same across the experience distribution. Strategic competitive responses may additionally be muted by what appear to be larger union influences. Since my results indicate that union influence may tend to result in deferred compensation, it may be useful to promote additional socialization of novice teachers into their unions, so that their interests are sufficiently represented at the bargaining table. This may be mutually beneficial for school districts and their unions, as it may facilitate more frontloaded, and thus more competitive, compensation structures while also fostering union attachment among novice teachers. This latter consideration may be particularly salient in the present moment, as public sector unions work to provide value to members even in what is often a hostile legal and political environment (Han and Keefe 2023; Marianno 2015). Still, future work should explore what other factors, including those driven by unions or specific aspects of CBAs, facilitate or constrain competition for teachers in school districts and how competitive behavior by districts operates dynamically, over longer time horizons.

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Tables

Table 1 – Summary Statistics

	N	Mean	SD	Min	Max
=1 if Elementary District	4980	0.46	0.50	0	1
=1 if High School District	4980	0.10	0.31	0	1
=1 if Unified District	4980	0.44	0.50	0	1
% Hispanic	4980	46.09	27.39	0	100
% Black	4980	3.40	4.97	0	62.71
% FRL	4980	53.25	25.91	0	100
Enrollment	4980	8432.24	11543.96	39	117644
=1 if Declining Enrollment	4980	0.56	0.50	0	1
Service Days for Returning Teachers	4980	183.78	2.31	173	195
BA+60 Salaries (Thousands of Dollars)					
Step 1	4980	55.36	6.51	34.99	119.27
Step 2	4980	57.35	6.83	40.32	119.55
Step 3	4980	59.56	7.17	40.51	122
Step 4	4980	61.86	7.60	42.94	124.73
Step 5	4980	64.16	8	43.80	124.73
Step 6	4980	66.50	8.40	44.67	124.73
Step 7	4980	68.84	8.79	45.57	124.73
Step 8	4980	71.20	9.22	46.48	129.68
Step 9	4980	73.60	9.67	47.41	134.80
Step 10	4980	76.08	10.20	48.35	139.77
Step 11	4980	78.35	10.67	49.32	144.82
Step 12	4980	80.37	11.04	50.31	149.86
Step 13	4980	81.72	11.17	51.31	149.86
Step 14	4980	82.66	11.25	52.34	149.86
Step 15	4980	83.61	11.45	53.39	149.86
Step 16	4980	84.37	11.61	53.39	149.86
Step 17	4980	84.89	11.76	53.39	152.63
Step 18	4980	85.45	11.91	53.39	152.63
Step 19	4980	85.86	12.03	53.39	152.63
Step 20	4980	86.58	12.26	53.39	152.63
Step 21	4980	87.14	12.52	53.39	155.39
Step 22	4980	87.47	12.61	53.39	155.39
Step 23	4980	87.77	12.78	53.39	155.39
Step 24	4980	88.11	12.97	53.39	155.39
Step 25	4980	88.76	13.27	53.39	155.39
Step 26	4980	89.06	13.45	53.39	155.39
Step 27	4980	89.29	13.60	53.39	155.39
Step 28	4980	89.44	13.67	53.39	155.39
Step 29	4980	89.51	13.72	53.39	155.39
Step 30	4980	89.84	13.86	53.39	155.39

Note. Data in this table combines annual observations of 498 unique districts from 2009-2010 through 2018-2019. Salaries are in thousands of 2020-2021 dollars.

Figures

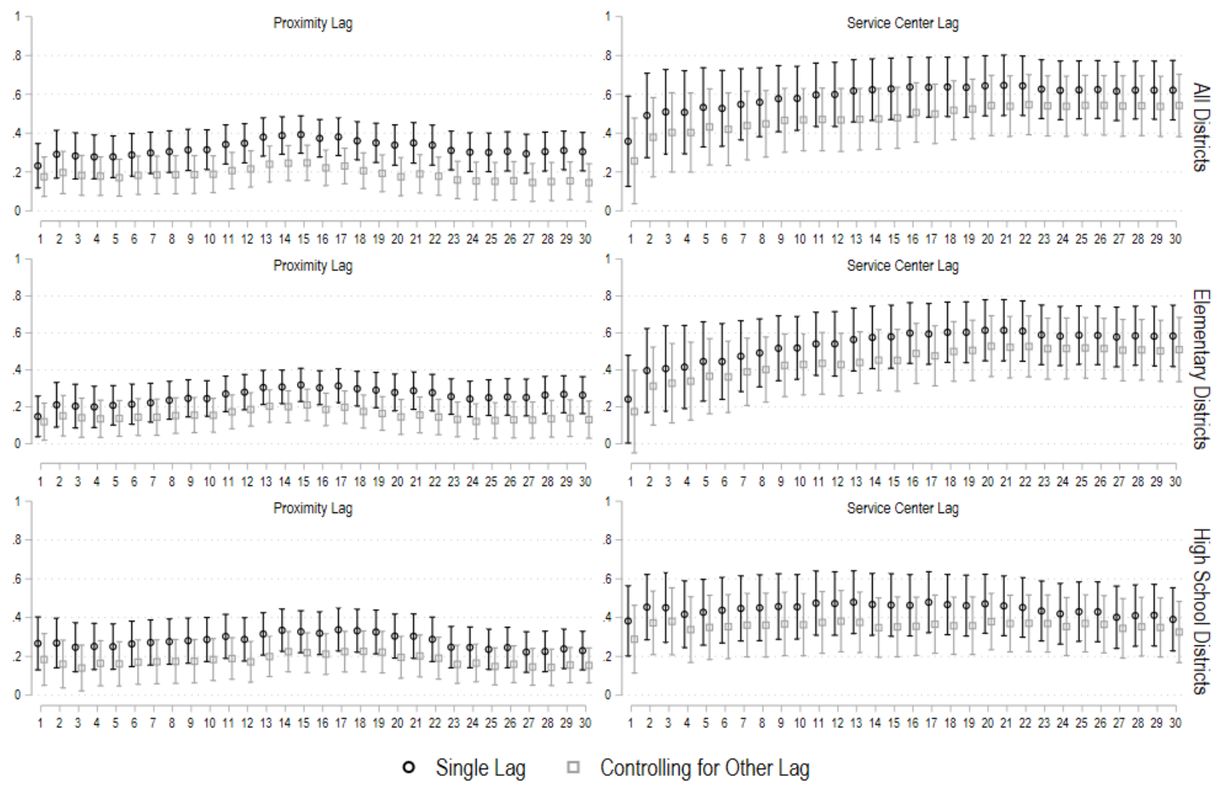

Figure 1. Spatial salary spillovers at each step of the salary schedule for teachers with a bachelor's degree and 60 additional credits. Each coefficient represents the point estimate (and associated 95% confidence interval) of $\boldsymbol{\rho}_1$ (on the left) and $\boldsymbol{\rho}_2$ (on the right) from model 1. Black markers are from variations of model 1 that include only the spatial lag term in question. All models are estimated with strongly balanced panels of annual district-level observations from the 2009-2010 through the 2018-2019 school years, inclusive. Estimates from "All Districts", "Elementary Districts", and "High School Districts" include 498, 446, and 269 unique districts, respectively.