TEACHER SALARIES AND TEACHER UNIONS: A SPATIAL ECONOMETRIC APPROACH

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The author uses a spatial econometric framework to examine the determinants of teacher salaries in the United States, including union activity in the teachers' own and in neighboring districts, teacher salaries in nearby districts, and other school district characteristics such as size and student-teacher ratios. Using the 1999–2000 Schools and Staffing Survey as well as the School District Demographic System and Bureau of Labor Statistics data sets, he finds that union activity (measured by the legal status of collective bargaining and teacher union membership density) increases salaries for experienced teachers by as much as 18 to 28%; it increases salaries for beginning teachers, however, by considerably less. Results also confirm that salaries for experienced and beginning teachers are positively affected by the salaries of teachers in nearby districts. A one-percent increase in the distance-weighted average of teacher salaries in nearby districts increases salaries in a given district by 0.52% for experienced teachers and 0.66% for beginning teachers. Studies that ignore such spatial dependence are likely to be mis-specified and may lead to misleading conclusions.

Teacher pay is an issue that has received much attention from researchers, politicians, and the general public and is thus important for several reasons. For one, state and local governments spend a large portion of their budgets on education. For the 2005–2006 school year, public school districts in the United States had current expenditures per pupil of $9,138, with more than 60% of current expenditures going toward teacher salaries and benefits (U.S. Census Bureau 2006a). Teacher pay is also important because of the sheer number of public school teachers in the United States. In 2006, for example, more than 4.6 million full-time equivalent (FTE) elementary and secondary teachers were employed by state and local governments, making teachers by far the largest group of government employees (U.S. Census Bureau 2006b). Teacher pay is also likely to affect the ability of school districts to recruit and retain quality teachers, as suggested by a sizable literature in education finance (e.g. Murnane and Olsen 1989, 1990; Figlio 1997, 2002; Clotfelter et al. 2008).

In this study, I use a spatial econometric framework to examine the determinants of teacher salaries in the United States, which includes teacher salaries in nearby districts, union activity in the district (measured by collective bargaining coverage), union activity in neighboring districts (measured by the

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proportion of districts with collective bargaining coverage and the teacher union membership density in the state), and other school district characteristics. A large body of literature has examined the determinants of teacher salaries, much of which has paid particular attention to the effects of unions. These studies have generally found that unions increase teacher salaries. Only a handful, however, account for the possible effects of teacher salaries in nearby districts. Because teachers can leave low-paying districts for higher-paying ones nearby, their salaries are very likely to be positively affected by the salaries of teachers in nearby districts.

The few studies that do examine the effects of teacher salaries in nearby districts analyze individual states. By investigating only school districts from a single state, however, such narrowly focused studies may miss important insights. Mine is apparently the first study to examine teacher salaries in a spatial econometric framework for the 48 contiguous U.S. states. I devote considerable attention to the effect of unions on teacher salaries and employ several different measures of union activity. In particular, I differentiate between the effects of union activity in the district and in the state.

Previous Literature and Theoretical Framework

Numerous studies have investigated the determinants of teacher salaries, with many focusing specifically on how these are affected by teacher unions.[1] Some have suggested, for example, that the effect of unions on the level and structure of teacher salaries should be determined by union goals and bargaining power, and a number of models have emerged in attempts to explain these goals (Hirsch and Addison 1986; Kaufman 2002). For example, union leaders have been assumed to maximize the total wage bill, the utility of a representative union member, or the utility of the median union member. Moreover, the goals of union leaders may often differ from those of union members (Pencavel 1991; Booth 1995). Union leaders may be first and foremost concerned with the survival and growth of the union, for example, if they are relatively more concerned about the long- rather than short-term well-being of their members. Bargaining power derives from numerous factors, including state collective bargaining laws, the extent of organizing, political support, and financial ability to pay.

Previous empirical studies have typically regressed the log of average salaries on union activity measures and other characteristics of the school district and local labor market. Results have varied considerably across studies, in part because of the different methods of measuring teacher salaries and union activity, differences across states, and differences over time. A few studies, such as Lovenheim (2009), found little to no effect of union activity on teacher salaries, but most have found at least a modest positive effect. Hoxby's (1996) finding of a roughly 5% effect of collective bargaining representation on average teacher salaries is fairly representative of most studies. At the same time, at least a few studies found union effects as large as 20% of wages (e.g., Baugh and Stone 1982; Zwerling and Thomason 1995).

A few studies have also recognized that teacher unions might differentially affect the salaries of teachers within a given district. In other words, unions affect not only the average level but also the distribution of salaries within a district. Holmes (1976) found that unions increase both the return to experience and the return to education within a district. Similarly, Delaney (1985) found that collective bargaining increases the salary differential between experienced and inexperienced teachers. Zwerling and Thomason (1995) and Lentz (1998) also found that although unions have a positive and significant effect on the salaries of teachers earning the highest salary in a district, unions have a small (though still positive) and statistically insignificant effect on the lowest salary in a district. Additionally, Babcock and Engberg

[1] See Lipsky (1982), Ehrenberg and Schwarz (1986), and Freeman (1986) for early literature reviews on the effects of unions on teacher salaries.

(1999) and Ballou and Podgursky (2002) suggested that the average levels of teaching experience and education in a district affect the returns to experience and education as well.

The effect of teacher unions on intra-district salary differentials is often explained by appealing to a median voter model. If union preferences are determined by a simple-majority vote, individual preferences are single-peaked, and there is only one outcome to be decided, the preferences of the median voter will be decisive. Virtually all public school districts, including those without collective bargaining, pay teachers according to a salary schedule that maps salary to teaching experience and education.[2] In the absence of union pressures, district administrators may dictate a salary schedule that is more appealing to marginal teachers than median teachers, with the former likely being those with little or no teaching experience and without advanced degrees. However, the union's preferred salary structure may be heavily influenced by the preferences and hence characteristics (such as experience and education) of the median teacher in the district. According to data tabulated from the 1999–2000 Schools and Staffing Survey (SASS) Teacher Survey, about half of public school teachers in the United States had advanced degrees and the average experience was about fifteen years.

Because there are multiple dimensions to union contracts (returns to experience, returns to education, the level of fringe benefits, and so on), the median voter model may not adequately explain the salary determination process within districts. Having multiple choice variables means that there is potentially no single median voter whose preferences are decisive. Instead, it may be useful to more generally view union preferences as resulting from a majority coalition of teachers. Union cohesion may even require that there be a super-majority coalition. Even with multiple choices to be made, though, it still seems likely that teachers with median levels of experience and education will be important members of the majority coalition and will push for a salary structure that benefits them. Teachers with little or no experience are the ones most liable to be left out of the majority coalition for several reasons. First, inexperienced teachers may be less likely to be members of the union and less likely to be active in the union when they are members. Additionally, union contracts are often negotiated months or even years in advance of the school year for which they apply. As a result, the very newest teachers never voted on how the salary schedule would be structured. School district administrators, however, are apt to be sensitive to market conditions for new teachers since this is when they are most mobile. Thus, we might expect unionized districts with strong union bargaining power to respond to the preferences of experienced (median voter) teachers whereas nonunion districts or union districts where bargaining power is weak may be more responsive to market conditions for new teachers.

Even if the median voter model is not perfectly applicable, it is reasonable to expect that unions might increase the salary differential between beginning and experienced teachers. Unions might also increase the salary differential between teachers with and without advanced degrees. This shifting in the salary structure may even result in less experienced teachers earning lower salaries than would be the case in the absence of union negotiations.

Chambers (1977), Delaney (1985), and Zwerling and Thomason (1995) suggested that teachers' salaries in a district are positively affected by union activity in nearby districts. In fact, all three studies suggest that the union spillover effect on wages is larger than the direct effect on wages of union

[2] A number of education finance reformers, however, have advocated a movement away from the so-called "single salary schedule" for teachers based on experience and education and toward a teacher compensation system based heavily on student performance. In Florida, for example, the state legislature recently passed a bill (SB 6), later vetoed by the Governor, that among other things would have eliminated teacher pay based on experience and education and instead based it heavily on student scores on standardized tests. Following the election of a more conservative state government in 2010, a similar bill was quickly passed and signed in the 2011 legislative session.

activity in the district. I use the term "*union* spillovers" to refer to the effects that union activity in nearby districts have on teacher salaries in a given district. Such spillovers are likely to result from a number of sources, including pattern bargaining, union threat effects, and the political influence of unions on state and local policymakers.

Studies by Wagner and Porter (2000), Greenbaum (2002), Babcock, Engberg and Greenbaum (2005), and Millimet and Rangaprasad (2007) found, using spatial econometric methods, that teacher salaries in a district are also positively influenced by teacher salaries in nearby districts.[3] I use the term "*wage* spillovers" to refer to the effects that teacher salaries in nearby districts have on teacher salaries in a given district. The studies noted above consistently found evidence of positive wage spillovers, at least in the states considered.[4] However, each of these studies examined a single state, and with the exception of Babcock et al. (2005), did not focus generally on the effects of unions. In this study, however, I contribute to the literature by using a national-level dataset to examine the effect of unions on teacher salaries in a spatial econometric framework. There are a number of benefits to using a multi-state analysis. First, union effects likely differ across states, and by looking at multiple states, we may get a better idea about the average effects of unions in the United States. Though analyses of particular states are certainly important, the average effects across the United States are quite important for an understanding of the effects of unions. A second major benefit of a multi-state analysis is that it allows for the estimation of the effects of state-level union activity variables, which include union spillover effects, whereas a single-state analysis would not.

Unions are also likely to affect school districts in ways other than increasing teacher salaries. For one, they may potentially affect the level of fringe benefits that teachers receive as part of their compensation package. Moreover, unions are likely to work toward better health insurance benefits, better pension benefits, and greater job security for the teachers they represent. Unions may also affect other school district characteristics, such as the student-teacher ratio and the level and composition of non-instructional expenditures. Perhaps most importantly, the overall influence of unions may affect the amount that students learn through altering inputs into the production of education and by empowering teachers. For the purposes of this paper, however, I focus on the effect of unions on the salaries that teachers are paid. Additional effects that unions might have on school districts are beyond the scope of my study.

Empirical Framework

Most previous studies of the determinants of teacher salaries do not account for the effect of teacher salaries in nearby districts. The usual estimation equation in these studies is given by

$$Y = X\beta + u, \tag{1}$$

where Y is an $n \times 1$ vector of teacher salaries (usually measured in logs), X is an $n \times K$ matrix of explanatory variables including union activity variables, β is a $k \times 1$ vector of parameters, and u is a mean zero error term assumed to be i.i.d. across observations.

I consider the possibility that teacher salaries are spatially correlated after controlling for other determinants of teacher salaries. The primary concern is that teacher salaries in one district may be affected by teacher salaries in neighboring districts, that is, there might be wage spillovers. This type of spatial dependence is likely to occur for several reasons. First, school districts likely compete with nearby districts for quality teachers. If one district offers salary levels substantially

[3] Ready and Sandver (1993) also found that salaries in one district are correlated with salaries in nearby districts. Their analysis, however, was based on OLS and did not account for the simultaneity of salaries for districts in close proximity with one another. As I discuss in more detail in the next section, appropriate spatial methods account for the simultaneity in teacher salaries using instrumental variables.

[4] Wagner and Porter (2000) examined school districts in Ohio; Greenbaum (2002) and Babcock et al. (2005) examined districts in Pennsylvania; and Millimet and Prangasad (2007) examined districts in Illinois.

below that of nearby districts, they will have difficulty hiring and retaining quality teachers. Thus, school district administrators have incentives to keep teacher salaries, especially starting salaries, competitive with those in nearby districts. Furthermore, comparisons of salaries in nearby districts are almost always used in contract negotiations between administrators and teacher unions. Similarly, many state laws prescribe interest arbitration when district administrators and union representatives reach an impasse, and decisions are often made on the basis of comparability with other districts. Spatial dependence in teacher salaries is therefore quite likely. If there is spatial correlation in the dependent variable, then methods that do not account for this are likely to produce inconsistent coefficient estimates (Anselin 1988). A second concern is that there may be spatial correlation in the error term, say from spatially correlated unobservable characteristics or spatially correlated measurement error in explanatory variables (Kalenkoski and Lacombe 2008). Failing to account for this in the error term may result in standard errors that are inconsistently estimated, especially for the union activity measures employed in this paper. Although a spatially correlated dependent variable and a spatially correlated error term are similar, there are important differences. Spatial correlation in the dependent variable suggests that districts are directly responding to each other either through competition or in an attempt to maintain comparability. Spatial correlation in the error term is more indirect and results from nearby districts responding similarly to common nearby forces such as state laws.

The spatial model in this paper can be represented by

$$\text{(2)} \qquad \begin{aligned} Y &= \rho W_1 Y + X\beta + u \\ u &= \lambda W_2 u + \varepsilon, \end{aligned}$$

where Y is again an $n \times 1$ vector of teacher salaries that now appears on both the left- and right-hand side of the equation, X is again an $n \times k$ matrix of explanatory variables including union activity variables, W_1 and W_2 are $n \times n$ weighting matrices that specify the structure of the spatial correlation for the dependent variable and the error term, ρ and λ are spatial autocorrelation coefficients for the dependent variable and the error term, and ε is a mean zero error term that is i.i.d. across observations. Some spatial econometric studies only model spatial correlation in the dependent variable (by assuming that $\lambda = 0$) or in the error term (by assuming that $\rho = 0$). After conducting numerous spatial econometric tests suggested by Anselin et al. (1996), I concluded that it was appropriate to account for spatial correlation in both the dependent variable and in the error term. A number of studies also use the same weight matrix for W_1 and W_2, but this can lead to identification issues.

Determining who the relevant neighbors are and how to weight them are important issues in spatial econometric studies. Most studies specify spatial weight matrices based on geographic proximity, but other concepts of "nearness" are also possible. For example, Gerwin (1973) reported that the city of Milwaukee was more concerned with teacher salaries in other large urban school districts than with those in its suburbs. Thus, one might consider weighting districts by similarity in enrollment levels. I follow the bulk of the previous literature, however, and specify W_1 based on the distance between school districts. For row i of the W_1 matrix, districts that are more than 50 miles away from i are given zero weight. In other words, districts are only considered neighbors if their centroids, that is, their geographic centers, are within 50 miles of each other. Districts within 50 miles of i are weighted based on their inverse distance to i, so that nearer districts are given more weight than districts farther away. I explored several additional weight matrices for W_1, such as altering the distance cutoff to 30 miles and 100 miles and equally weighting all districts within the cutoff. I ultimately chose the 50-mile cutoff to keep the group of neighbors as tight as possible while minimizing the number of districts that must be excluded due to not having any neighbor in the sample. The inverse distance specification was chosen based on the assumption that salaries in a district are most strongly affected by salaries in other districts that are closest to it, the effect attenuating with distance.

I also explored the possibility of using an inverse-distance weight matrix with a 50-mile cutoff that also requires neighbors to be in the same state, but the interstate neighbors were ultimately retained because wage spillovers are likely to spread across state borders. The results are, for the most part, qualitatively robust across various weight matrices. The weight matrix for the spatial error term, W_2, is specified such that for district i all other districts in the same state are treated as neighbors and given equal weight. This specification captures spatial error correlation due to common unobserved factors within states. Each weight matrix is also structured so that the elements in each row sum to unity and all diagonal elements are equal to zero so that a district cannot be its own neighbor. In other words, W_1Y is a distance-weighted average of teacher salaries in nearby districts, and W_2u is an un-weighted average of the error terms of other districts in the same state.

It should be clear that teacher salaries in neighboring districts are hypothesized to be simultaneously determined. Salaries in district j affect salaries in district i, just as salaries in district i affect salaries in district j. Because of the simultaneity involved, using Ordinary Least Squares (OLS) to estimate the spatial model is inappropriate. Instead, instrumental variable methods are used. More specifically, I estimate the spatial models by the Generalized Method of Moments (GMM) estimator developed by Kelejian and Prucha (1998) using the Spatial Econometrics Toolbox for MATLAB developed by James LeSage and described in LeSage (1999). The GMM estimator instruments for W_1Y using W_1X and W_1^2X as instruments. In other words, the estimator instruments for salaries in nearby districts using the distance-weighted averages of the other explanatory variables in nearby districts along with the distance-weighted averages of their neighbors' neighbors' characteristics. Kelejian and Prucha (1998) outlined the conditions under which the GMM estimator provides consistent estimates.

Data

The primary data used in this analysis come from the school district survey of the 1999–2000 Schools and Staffing Survey (SASS) conducted by the National Center for Education Statistics (NCES) and completed by school district administrators. There may be potential drawbacks to using cross-sectional data because wage spillovers might not always be contemporaneous. Unions and district administrators often reference contracts negotiated in other districts in prior years and contracts often last for multiple years (Babcock et al. 2005). Information on when a contract was agreed to might provide additional insights about the nature of wage spillovers, but the SASS does not collect this information. Still, there are important insights to be gained from the cross-sectional analysis I undertake in this study. I obtained additional data from the NCES Common Core of Data (CCD), the NCES School District Demographics System (SDDS), the Bureau of Labor Statistics (BLS) Local Area Unemployment Statistics (LAUS), and the NCES Comparable Wage Index (CWI) developed by Taylor and Fowler (2006). The CWI measures the wages in the local labor market of occupations comparable to teaching based on microdata from the 2000 decennial Census and is available for nearly every district in the SASS. Table 1 provides summary statistics for the variables used in the study and documents the source for each.

The SASS sample originally included more than 4,600 school districts, or about one-fourth of all districts in the United States. A number of observations were lost, however, due to missing data values as well as to not having a neighbor in the sample within 50 miles. The final sample includes 4,237 school districts in the 48 contiguous states. The fact that all districts are not included could pose problems for the spatial results since salaries for some of a district's neighbors are not observed. The key assumption is that for each district, the neighbors that are observed are not statistically different from the ones that are not observed. In other words, the included neighbors are representative of the excluded neighbors. If so,

Table 1. Summary Statistics and Data Sources

Variable	*Mean*	*Std. Dev.*	*Min*	*Max*	*Source*
Salary BA0	25,901	3,802	16,350	43,085	SASS
Salary MA20	48,986	11,349	20,775	98,207	SASS
Collective Bargaining	0.612	0.487	0	1	SASS
Meet and Confer	0.078	0.268	0	1	SASS
State Collective Bargaining Share	0.567	0.410	0	1	SASS
State Union Membership	0.765	0.185	0.312	0.992	SASS
Days of School	178.614	4.691	142	288	SASS
Student-Teacher Ratio	15.086	3.904	3.088	107.241	SASS
Share of Secondary Teachers	0.386	0.158	0	1	SASS
Share of Teachers Dismissed	0.007	0.021	0	0.491	SASS
% Δ Enrollment, 1994–1999 (/100)	0.039	0.174	–0.658	4.452	CCD
Log Enrollment	7.787	1.433	3.367	13.905	SASS
Herfindahl Index	0.158	0.145	0.013	1	CCD
Share of White Students	0.763	0.272	0	1	SASS
Share of Low Income Students	0.397	0.250	0	1	SASS
Log of Comparable Wage Index	–0.118	0.123	–0.352	0.218	CWI
Share HS Plus	0.796	0.099	0.201	1	SDDS
Share BA Plus	0.194	0.118	0.016	1	SDDS
Share w/ Children <18	0.319	0.054	0.123	1	SDDS
Share of Homeowners	0.734	0.115	0	0.970	SDDS
County Unemployment Rate	0.046	0.026	0.007	0.301	LAUS
Log of Median Home Value	11.385	0.531	9.547	13.604	SDDS

Notes: The dataset contains observations on 4,237 school districts included in the 1999–2000 Schools and Staffing Survey (SASS). Additional data are from the National Center for Education Statistics (NCES) Common Core of Data (CCD), the NCES Comparable Wage Index (CWI), the NCES School District Demographics System (SDDS), and the Bureau of Labor Statistics Local Area Unemployment Statistics (LAUS).

the GMM estimates will be consistent. The high degree of spatial correlation in both the dependent variable and the error term in the results shown below at least partially alleviates concerns that the included neighbors might not be representative of the excluded neighbors.

The teacher salaries investigated for both beginning teachers and experienced teachers come from the 1999–2000 SASS. Beginning teacher salaries are measured by the base salary according to the district's salary schedule for teachers with no teaching experience and only a bachelor's degree (BA0). Salaries for experienced teachers are measured by the base salary on the district's salary schedule for teachers with 20 years of teaching experience and a master's degree related to the teaching field (MA20).[5] Individual teachers are sometimes paid amounts above that required by the salary schedule for special credentials or extra duties such as coaching a sports team. However, the salary measures used in this study are for the base salary in the district and do not include extra pay for special credentials or extra duties. Beginning teachers in the sample earn a mean salary of $25,901 whereas experienced teachers earn nearly twice that. There is also greater variation in the salaries of experienced teachers. The standard deviation in salaries for experienced teachers is nearly three times that of beginning teachers, and the coefficient of variation (CV) for experienced teachers of 0.232 is more than 1.5 times the CV for beginning teachers of 0.147.

[5] The SASS also reports the salary for teachers with only a bachelor's degree and ten years of experience (BA10). In results not shown, I also examine the determinants of this variable and generally find results that fall between those for BA0 and MA20.

The regression analysis below includes a number of important explanatory variables. I give considerable emphasis to the effect of unions and measure union activity in three different ways. I first measure it by two mutually exclusive indicator variables for collective bargaining and the presence of a meet and confer agreement in the district. Meet and confer agreements generally stipulate that district administrators are to meet and confer with teacher representatives about salaries, benefits, and working conditions, but they do not legally compel the district to reach an agreement with a teachers' union. They tend to be concentrated in a handful of states with meet and confer laws and weak collective bargaining laws. Because they are not binding on school districts, meet and confer agreements are likely to result in less favorable outcomes for teachers. As Table 1 shows, more than 61% of the districts engage in collective bargaining, and another 8% have meet and confer agreements. Thus, roughly 31% of districts have neither. Previous literature has suggested that union activity in neighboring districts has important spillover effects, and the next two measures of union activity will produce estimates that include these effects from other districts in the same state.

My second measure of union activity is the share of districts with a collective bargaining agreement in a state.[6] If collective bargaining has important spillover effects on teacher salaries for other districts in the state, the effect for the state collective bargaining share should be greater than the effect for the collective bargaining indicator variable. My third measure of union activity is the percentage of teachers in a state who are members of a teacher union, the effects for which will also include union spillovers. Union membership at the district level is not available, however, so the effects of state membership density cannot be compared to those of district membership density. Though the second and third measures of union activity are both intended to include union spillover effects, they are different measures and could produce somewhat different results. One limitation of this paper is that all of the union activity measures are treated as exogenous. If union activity is in fact endogenous because of simultaneity, omitted variables, or measurement error, coefficient estimates could be biased and inconsistent.

My analysis also includes a number of other important variables thought to affect teacher salaries. (a) Teachers are expected to require greater compensation for longer school years, so the number of days in the school year is expected to have a positive sign. (b) Teachers generally prefer smaller classes, so the student-teacher ratio is expected to have a positive coefficient, as Vedder and Hall (2000) have discovered. (c) Secondary teaching is thought to be more difficult and require greater skills, so the share of secondary teachers is expected to have a positive coefficient (Walden and Sogutlu 2001). (d) Districts may be more likely to dismiss teachers for poor performance when they have weaker demand for teachers, so districts having dismissed relatively large numbers of teachers recently are expected to have a lower need for teachers and to pay less competitive salaries.[7] (e) Districts having experienced increased enrollments over the previous five years are expected to have a high demand for teachers and to be willing to pay higher relative salaries (Zwerling and Thomason 1995). (f) Similarly, larger districts are expected to pay higher salaries, and the log of district enrollment is expected to have a positive coefficient (Walden and Newmark 1995).

Some researchers (e.g., Merrifield 1999 and Taylor 2010) have suggested that monopsony power in the local teacher labor market adversely affects teacher salaries. This is yet another variable, (g), thought to affect teacher salaries. To account for this, the

[6] I also experimented with measuring union activity by the state share of districts with any agreement, that is, either collective bargaining or a meet and confer agreement. The results are qualitatively similar to the results for the share with collective bargaining and are available upon request by emailing the author.

[7] It could instead be the case that higher salaries lead districts to dismiss more teachers when budgets are especially tight, leading to a positive coefficient.

regressions include the local labor market teacher employment Herfindahl Index (HI) as a measure of employer concentration. The HI is computed as the sum of the squared market shares of all school districts in a local labor market, including ones not in the sample, and it is expected to have a negative coefficient. (h and i) Teachers may require compensating differentials to teach minority students and students from disadvantaged backgrounds, so the share of students who are white is expected to have a negative effect whereas the share of low-income students as measured by free or reduced lunch eligibility is expected to have a positive effect (Martin 2010). (j) The log of the Comparable Wage Index is included to control for the relative cost of living in a particular labor market and to serve as a proxy for the opportunity cost of teaching in a given market (Stoddard 2005).[8] A higher level of comparable wages is expected to increase teacher salaries. (k and l) More educated residents are thought to have greater demand for education, so the share of adults (age 25+) living in the district with at least a high school degree and the share of adults with at least a bachelor's degree are expected to have positive coefficients (Taylor 2010). (m) Residents with children are expected to demand greater spending on education, so the share of households with at least one child under age 18 is expected to have a positive effect (Easton 1988). (n) Renters are thought to be more likely than homeowners to support spending on education, perhaps in part because renters do not believe that they bear the burden of local property taxes to finance education, so the share of households who are homeowners is expected to have a negative effect (Martinez-Vasquez and Sjoquist 1988). (o) The unemployment rate in the county in which the district is located is also included to capture local labor market conditions. Higher unemployment is likely to make it more difficult to find a well-paying career outside of teaching and is expected to have a negative effect on teacher salaries (Taylor 2010). (p) Finally, some studies (e.g., Lentz 1998 and Winters 2009) have suggested that districts with a greater property tax base pay higher teacher salaries. Therefore, the log of the median value of owner-occupied housing in the district is included as a proxy for the property tax base and is expected to have a positive effect.

The regressions performed in this study include a large number of variables and some of them are highly correlated with each other (e.g., Log CWI and the Log of Median Home Values have a correlation of 0.68), which could lead to problems with multicollinearity. However, with more than 4200 observations, multicollinearity problems should be mitigated.

Empirical Results

I begin by estimating Equation (1) using OLS, but spatial autocorrelation is likely to be present in both the dependent variable and the error term. Preliminary evidence on the presence of spatial autocorrelation in log teacher salaries can be obtained from Moran's (1950) I statistic. The log of experienced teacher salaries has an I statistic of 96.14 and the log of beginning teacher salaries has an I statistic of 95.53, meaning in both cases that the null of no spatial autocorrelation can be rejected at the .01 level of significance. Therefore, I also estimate the spatial model of Equation (2) using GMM. Results that measure union activity by collective bargaining and meet and confer indicator variables are discussed first and reported in Tables 2 and 3 for experienced and beginning teachers, respectively. Tables 4 and 5 re-estimate the equations in Tables 2 and 3 separately measuring union activity by the share of districts in the state with a collective bargaining agreement and the share of teachers in the state who are members of a teacher union.

Importantly, the marginal effects of the exogenous variables in the spatial models are not equal to their coefficient estimates. In the spatial results below, I report coefficient estimates, standard errors in parentheses, and average marginal effects in brackets

[8] Hedrick et al. (2011) showed that controlling for the cost of living has a considerable effect on estimates of the union salary premium for college and university faculty.

Table 2. Log Salary Regressions for MA20 with Union Indicator Variables

	1	*2*
Spatial Lag (ρ)		0.6441***
		(0.0403)
Spatial Error (λ)		0.5958***
		(0.0018)
Collective Bargaining	0.0966***	0.0336***
	(0.0054)	(0.0062)
		[0.0368]
Meet and Confer	0.0030	0.0236***
	(0.0083)	(0.0067)
		[0.0259]
Days of School (/100)	0.3410***	0.0872**
	(0.0451)	(0.0373)
		[0.0957]
Student-Teacher Ratio (/100)	–0.1540**	0.0963*
	(0.0636)	(0.0516)
		[0.1057]
Share of Secondary Teachers	0.0590***	0.0453***
	(0.0135)	(0.0111)
		[0.0497]
Share of Teachers Dismissed	–0.0863	–0.0370
	(0.0984)	(0.0737)
		[–0.0406]
% Δ Enrollment, 1994–1999 (/100)	0.0166	0.0220**
	(0.0126)	(0.0097)
		[0.0242]
Log of Enrollment	0.0224***	0.0215***
	(0.0020)	(0.0017)
		[0.0236]
Herfindahl Index	–0.1083***	–0.0274**
	(0.0152)	(0.0128)
		[–0.0494]
Share of White Students	–0.0150	–0.0286***
	(0.0109)	(0.0089)
		[–0.0314]
Share of Low Income Students	–0.0505***	–0.0115
	(0.0114)	(0.0087)
		[–0.0126]
Log of Comparable Wage Index	0.7999***	0.2172***
	(0.0264)	(0.0281)
		[0.3920]
Share HS Plus	–0.0297	–0.0385
	(0.0379)	(0.0301)
		[–0.0422]
Share BA Plus	0.0500	0.1741***
	(0.0309)	(0.0244)
		[0.1910]
Share w/ Children<18	–0.3364***	–0.1079***
	(0.0405)	(0.0318)
		[–0.1184]
Share of Homeowners	0.0219	–0.0030
	(0.0217)	(0.0170)
		[–0.0033]

continued

Table 2. Log Salary Regressions for MA20 with Union Indicator Variables Continued

	1	*2*
County Unemployment Rate	0.8188***	0.2408***
	(0.0917)	(0.0755)
		[0.3399]
Log of Median Home Value	0.0720***	0.0285***
	(0.0080)	(0.0073)
		[0.0313]
Adjusted R^2	0.6177	0.7878

Notes: Regressions include 4,237 school districts included in the 1999–2000 SASS. Column 1 is estimated by OLS and column 2 is estimated by GMM. The dependent variable is the log of the salary for teachers with 20 years of experience and a Master's degree. Standard errors are in parentheses and average marginal effects are in brackets for the spatial model.
*Statistically significant at the .10 level; ** at the .05 level; ***at the .01 level.

computed as described in the Appendix. For ease of discussion, I often refer to the average marginal effects simply as the marginal effects, and I focus on these when discussing magnitudes for these variables. This is important because the marginal effects for some variables below are more than twice the size of the coefficient estimates. Note that coefficient estimates for the OLS equations can be directly interpreted as marginal effects because of the linearity assumption.

Spatial Correlation Coefficients

The results confirm that salaries are spatially dependent for both experienced teachers and beginning teachers even after controlling for many other variables that explain teacher salaries. The results in column 2 of Tables 2 and 3 report statistically significant spatially lagged dependent variable coefficients (ρ) of 0.64 and 0.69 for experienced and beginning teachers, respectively. According to these estimates, a 1% increase in the distance-weighted average of experienced teacher salaries in nearby districts increases salaries for experienced teachers in a given district by 0.64%. For beginning teachers, the effect of salaries in nearby districts is even stronger; a 1% increase in the distance-weighted average of salaries for beginning

Table 3. Log Salary Regressions for BA0 with Union Indicator Variables

	1	*2*
Spatial Lag (ρ)		0.6898***
		(0.0481)
Spatial Error (λ)		0.6190***
		(0.0072)
Collective Bargaining	0.0095**	–0.0039
	(0.0039)	(0.0040)
		[–0.0043]
Meet and Confer	–0.0181***	0.0052
	(0.0061)	(0.0047)
		[0.0058]
Days of School (/100)	0.1859***	0.0757***
	(0.0327)	(0.0257)
		[0.0848]
Student-Teacher Ratio (/100)	–0.1197***	0.0077
	(0.0462)	(0.0356)
		[0.0086]
Share of Secondary Teachers	0.0238**	0.0271***
	(0.0098)	(0.0076)
		[0.0303]
Share of Teachers Dismissed	0.0302	–0.0661
	(0.0715)	(0.0507)
		[–0.0741]
% Δ Enrollment, 1994–1999 (/100)	0.0234**	0.0204***
	(0.0092)	(0.0066)
		[0.0228]
Log of Enrollment	0.0192***	0.0133***
	(0.0015)	(0.0011)
		[0.0149]
Herfindahl Index	–0.0752***	–0.0212**
	(0.0110)	(0.0089)
		[–0.0416]
Share of White Students	–0.0381***	–0.0294***
	(0.0079)	(0.0062)
		[–0.0330]
Share of Low Income Students	–0.0278***	–0.0068
	(0.0083)	(0.0060)
		[–0.0076]
Log of Comparable Wage Index	0.5851***	0.1372***
	(0.0192)	(0.0201)
		[0.2690]
Share HS Plus	–0.2138***	–0.0765***
	(0.0276)	(0.0210)
		[–0.0858]
Share BA Plus	0.0824***	0.1053***
	(0.0225)	(0.0168)
		[0.1180]
Share w/ Children<18	–0.1906***	–0.0005
	(0.0294)	(0.0219)
		[–0.0006]
Share of Homeowners	0.0521***	–0.0134
	(0.0158)	(0.0118)
		[–0.0151]

continued

Table 3. Log Salary Regressions for BA0 with Union Indicator Variables Continued

	1	*2*
County Unemployment Rate	0.4302***	0.0708
	(0.0666)	(0.0522)
		[0.1055]
Log of Median Home Value	0.0412***	0.0204***
	(0.0058)	(0.0051)
		[0.0229]
Adjusted R^2	0.5581	0.7799

Notes: Regressions include 4,237 school districts included in the 1999–2000 SASS. Column 1 is estimated by OLS and column 2 is estimated by GMM. The dependent variable is the log of the salary for teachers with no experience and only a Bachelor's degree. Standard errors are in parentheses and average marginal effects are in brackets for the spatial model.
**Statistically significant at the .05 level; ***at the .01 level.

teachers in nearby districts increases salaries for beginning teachers by 0.69%. Although I use a national-level dataset, the spatially lagged dependent variable coefficients estimated herein are within the range of intrastate estimates by previous researchers. Wagner and Porter (2000) found a spatial lag coefficient of 0.51 for beginning teacher salaries in Ohio; Greenbaum (2002) reported a spatial lag coefficient of 0.66 for average teacher salaries in Pennsylvania; and Millimet and Prangasad (2007) estimated a spatial lag coefficient of 0.86 for average teacher salaries in Illinois. The spatial error coefficient (λ) is also statistically significant for both experienced and beginning teachers. The spatial error coefficient is 0.60 for experienced teachers in Table 2 and 0.62 for beginning teachers in Table 3.

Collective Bargaining and Meet and Confer Indicators

Estimating the effects of teacher unions on teacher salaries is a primary concern of this study. Previous studies have usually found that unions increase teacher salaries, at least for experienced teachers, but these studies do not generally account for spatial dependence in teacher salaries. For experienced teachers, the OLS results in this paper

Table 4. Log Salary Regressions for MA20 with State CB Share and Union Membership Density

	1	*2*	*3*	*4*
Spatial Lag (ρ)		0.5316***		0.5190***
		(0.0543)		(0.0611)
Spatial Error (λ)		0.6474***		0.6766***
		(0.0014)		(0.0013)
State Collective Bargaining Share	0.1747***	0.0837***		
	(0.0062)	(0.0166)		
		[0.1634]		
State Union Membership			0.3815***	0.1822***
			(0.0140)	(0.0436)
				[0.3471]
Adjusted R^2	0.6504	0.7876	0.6463	0.7866

Notes: Regressions include 4,237 school districts included in the 1999–2000 SASS. Columns 1 and 3 are estimated by OLS and columns 2 and 4 are estimated by GMM. The dependent variable is the log of the salary for teachers with 20 years of experience and a Master's degree. Regressions also include the additional non-union explanatory variables in Table 2. Standard errors are in parentheses and average marginal effects are in brackets for the spatial models.
*** Significant at the .01 level.

Table 5. Log Salary Regressions for BA0 with State CB Share and Union Membership Density

	1	*2*	*3*	*4*
Spatial Lag (ρ)		0.6898***		0.6649***
		(0.0503)		(0.0557)
Spatial Error (λ)		0.6300***		0.6558***
		(0.0069)		(0.0064)
State Collective Bargaining Share	0.0500***	0.0129		
	(0.0046)	(0.0081)		
		[0.0363]		
State Union Membership			0.1586***	0.0371*
			(0.0103)	(0.0218)
				[0.0975]
Adjusted R^2	0.5675	0.7795	0.5791	0.7790

Notes: Regressions include 4,237 school districts included in the 1999–2000 SASS. Columns 1 and 3 are estimated by OLS and columns 2 and 4 are estimated by GMM. The dependent variable is the log of the salary for teachers with no experience and only a Bachelor's degree. Regressions also include the additional non-union explanatory variables in Table 2. Standard errors are in parentheses and average marginal effects are in brackets for the spatial models.
*Statistically significant at the .10 level; ***at the .01 level

suggest that the presence of collective bargaining increases teacher salaries by roughly 10%. Accounting for the spatial nature of the data, however, the average marginal effect of collective bargaining for experienced teachers is only 0.037, suggesting that collective bargaining in a district increases salaries for experienced teachers by about 4%. Thus, it appears that failing to account for spatial dependence causes one to overstate the effects of collective bargaining in a district on the salaries of experienced teachers in that district. However, because collective bargaining is measured at the district level but may have spillover effects across districts, some of the observed wage spillover in Table 2 may be a union spillover. Below, I measure union activity by two state-level variables whose observed effects include union spillovers, the share of districts with collective bargaining in a given state, and the share of teachers in a state who are members of a teacher union.

For beginning teachers, accounting for spatial dependence has a similar effect on coefficient estimates for collective bargaining but on a much smaller scale. OLS suggests a small but statistically significant effect of collective bargaining, just less than 1%. The spatial model, however, reports a coefficient that is not statistically different from zero. Thus, consistent with previous literature, the GMM results in Tables 2 and 3 suggest that collective bargaining increases teacher salaries for experienced teachers but not for beginning teachers.

Tables 2 and 3 also include an indicator variable for the presence of a meet and confer agreement in the district. For experienced teachers, the meet and confer effect is statistically insignificant in the OLS specification. For the spatial results, however, meet and confer agreements have a significantly positive effect for experienced teachers with a marginal effect estimate of 0.026, which is slightly smaller than the effect of collective bargaining. For beginning teachers, the meet and confer effect in the OLS specification is actually negative and statistically significant though relatively small. Accounting for spatial dependence, though, the meet and confer effect for beginning teachers is not statistically significant.

Additional Explanatory Variables

The results in Tables 2 and 3 suggest that additional variables affect teacher salaries as well. These include characteristics of the teachers, the school district, the students, the local residents, and the local labor market. Importantly, the results for the spatial models are often quite different from the OLS results for the non-spatial models in the first column of the tables. Here I discuss the results for the spatial models in the second columns of Tables 2 and 3. Because the dependent variables are measured in logs, the marginal effects can be loosely interpreted as percentage changes. Note, however, that a few variables have been rescaled for estimation and presentation purposes. The length of the school year has a positive and statistically significant effect on the salaries of both experienced and beginning teachers with marginal effects of 0.096 and 0.085, respectively.

The student-teacher ratio has a positive effect on the salaries of experienced teachers, with a marginal effect of 0.106 that is statistically significant at the .10 level. However, the estimates suggest that increasing the student-teacher ratio by ten would only increase teacher salaries by about 1%, so the effect is relatively small. For beginning teachers, the student-teacher ratio effect is not statistically different from zero. For both experienced and beginning teachers, salaries increase with the percentage of teachers who teach secondary grades, with significant marginal effects of 0.050 and 0.030, respectively. This suggests that secondary teaching is either less pleasant or requires greater skills or greater effort than teaching primary grades (Walden and Sogutlu 2001).

The percentage of teachers dismissed in the previous year has a statistically insignificant coefficient for both experienced and beginning teachers. Consistent with expectations, enrollment and the growth in enrollment both have significantly positive effects on the salaries of experienced and beginning teachers. Enrollment growth has marginal effects of 0.024 for experienced teachers and 0.023 for beginning teachers. The log of enrollment has marginal effects of 0.024 for experienced teachers and 0.015 for beginning teachers. This may suggest that larger school districts are worse places to work and require compensating differentials (Walden and Newmark 1995). The Herfindahl Index has a statistically significant negative effect for both experienced and beginning teachers with marginal effects of –0.049 and –0.042, respectively. The share of students who are white has a negative and statistically significant effect for both experienced and beginning teachers, with marginal effects of –0.031 and –0.033, respectively. This is consistent with Martin (2010), who found that teachers require positive compensating wage differentials to work in districts with a higher percentage of minority students. The share of low-income students has a small coefficient for both and is not statistically significant.

The results also suggest that teacher salaries are affected by local labor market conditions and the local demand for education. The log of the comparable wage index, which measures teachers' opportunity cost of teaching in the local market, has a statistically significant effect for both experienced and beginning teachers, with marginal effects of 0.392 and 0.269. Thus, teachers require higher wages to teach in labor markets in which other occupations draw higher wages. Increases in the share of the adult population with a college degree significantly increases salaries for both experienced and beginning teachers, with marginal effects of 0.191 and 0.118. The share of the population with a high school degree or higher, however, has a statistically insignificant effect for experienced teachers and a significantly negative effect for beginning teachers with a marginal effect of –0.086. The share of households in a district with children under age 18 results in significantly lower salaries for experienced teachers, with a marginal effect of –0.118. This is in contrast to expectations that households with children would demand greater education services and would be willing to support higher teacher salaries. For beginning teachers, the effect of the share of households with children is small and statistically insignificant. The share of households in a district who are homeowners has a statistically insignificant effect on the salaries of both experienced and beginning teachers.

The county unemployment rate has a somewhat unexpected significantly positive coefficient for experienced teachers, with a marginal effect of 0.340, but the effect for beginning teachers is not statistically significant. Finally, the log of the median of home values in the district has a statistically significant positive effect on the salaries of both experienced and beginning teachers, with marginal effects of 0.031 and 0.023, suggesting that wealthier districts demand greater spending on education and this translates into higher teacher salaries.

Measuring Union Activity by the State Share of Districts with Collective Bargaining

The first two columns of Tables 4 and 5 present the results of re-estimating the equations in Tables 2 and 3 measuring union activity by the share of districts with collective bargaining in a state. For the sake of brevity, I report only results for the spatial variables and the state collective bargaining share. The results for the additional explanatory variables are qualitatively similar to the corresponding results in Tables 2 and 3 and are available from the author by e-mail. Measuring union activity by the state collective bargaining share, the spatial lag coefficient decreases to 0.53 for experienced teachers, shown in the second column of Table 4. This seems to confirm the earlier hypothesis that the spatial lag coefficient in Table 2 was partially capturing union spillovers. For beginning teachers, however, the spatial lag coefficient of 0.69 in the second column of Table 5 is identical to that in Table 3. The spatial lag coefficient is now significantly larger for beginning teachers than for experienced teachers. This result is likely due to the greater mobility of new than experienced teachers. District administrators may be especially concerned with keeping beginning salaries competitive in order to be able to hire and retain beginning teachers. Because experienced teachers are usually less mobile, spatial dependence in salaries for experienced teachers may result more from union efforts to keep salaries comparable to those in nearby districts. The spatial error coefficients are again statistically significant for both experienced and beginning teachers with estimates of 0.65 and 0.63, respectively.

The results in the second column of Table 4 also suggest that the share of districts with collective bargaining has a statistically significant effect on the salaries of experienced teachers, with a marginal effect of 0.163 in the spatial model. This is more than four times the effect of collective bargaining in the second column of Table 2, suggesting that the spillover effects from collective bargaining are considerably larger than the direct effect of collective bargaining in the district. For beginning teachers, in the second column of Table 5, the share of districts with collective bargaining has a small effect that is not statistically significant at conventional levels, suggesting that the state collective bargaining share has at best a weak effect on the salaries of beginning teachers. In results not shown here, I also estimated regressions that simultaneously included both an indicator variable for collective bargaining in a district and the state share of districts with collective bargaining. In these regressions, the effects for the indicator variable were virtually zero and statistically insignificant whereas the effects for the state collective bargaining share were virtually identical to the results in the second columns of Tables 4 and 5. These effects suggest that working in a state in which teachers are heavily unionized has a much more important effect on salaries for experienced teachers than working in a district with collective bargaining.

Measuring Union Activity by State Union Membership

Following Zwerling and Thomason (1995), I also measure union activity by the percentage of teachers in a state who are members of a teacher union. The third and fourth columns of Tables 4 and 5 present the results of re-estimating the equations in Tables 2 and 3, measuring union activity by state union membership. Again for the sake of brevity, I only report results for the spatial variables and the state union membership density. Results for the additional variables are qualitatively similar to previous results and are available upon request by writing to the author. Like the share of districts with collective bargaining in a state, the effect of the state union membership density includes union spillover effects. These two measures, however, could produce different results. For example, the state membership density could have a stronger effect if it is a better measure of union strength. A union bargaining in a district in which a large percentage of the teachers are union members is likely to have more power in contract negotiations. Furthermore, union members may be more active politically, even in districts without a collective bargaining agreement. The votes of teachers can be quite important in state and local elections, especially in school board elections, in which a relatively low percentage of the general population turns out to vote, but a larger percentage of teachers do (Moe 2006). When teachers are highly organized, school boards may feel significant pressure to concede higher salaries and other union demands.

The spatial lag and spatial error results in the fourth column of Tables 4 and 5 measuring union activity by the state membership share are very similar to the corresponding estimates in the second column of Tables 4 and 5. For experienced teachers, the state membership density has a significant marginal effect of 0.347. For beginning teachers, the state membership density is significant at the .10 level, with a marginal effect of 0.098. This is the first statistically significant effect of union activity on beginning teacher salaries to be mentioned in this paper. The marginal effects for the state membership density are larger in magnitude than the marginal effects for the collective bargaining share, but we must also account for the fact that the state membership density is less dispersed than the state collective bargaining share to assess their relative impacts. The state collective bargaining share has a minimum value of zero, a maximum value of one, and a standard deviation of 0.410, whereas the state membership density ranges between 0.312 and 0.992 and has a standard deviation of 0.185. Therefore, according to the estimates in Table 4, moving from a state with no collective bargaining to a state with complete collective bargaining coverage would increase salaries for experienced teachers by 17.8%; conversely, moving from the state with the lowest membership density to the state with the greatest membership density would increase salaries for experienced teachers by 28.2%. Alternatively, moving from one standard deviation below the mean to one standard deviation above the mean of union activity increases salaries for experienced teachers by 14.6% for the collective bargaining share and by 15.4% for the state membership density. Moving from the 25th percentile to the 75th percentile of union activity increases salaries for experienced teachers by 15.6% for the collective bargaining share and by 12.5% for the state membership density. Thus, although the two measures differ, their estimated impacts on the salaries of experienced teachers are both fairly large.

Conclusion

I have used spatial econometric techniques to investigate the determinants of teacher salaries in the United States. Of particular importance are the effects of teacher unions and the effects of teacher salaries in nearby districts. Including union spillover effects, I find that collective bargaining and union membership density in a given state increase salaries for experienced teachers by as much as 18 and 28%, respectively. The estimated effects of union activity on the salaries of beginning teachers, however, are much smaller, likely due to the relatively weak bargaining position of beginning relative to experienced teachers within unions.

Teacher salaries in one district are also affected by teacher salaries in nearby districts because of district competition for teachers, comparability requirements, and union bargaining strategies. These teacher wage spillovers flow in both directions, and the simultaneous nature of this relationship means that consistently estimating their effects requires using spatial econometric techniques. The results of this study demonstrate that teacher salaries are indeed spatially autocorrelated for both experienced and beginning teachers. Previous literature has found evidence of spatial autocorrelation in teacher salaries for individual states, but this is the first study to examine spatial dependence in teacher salaries for the 48 contiguous U.S. states. Though I use a national-level dataset, the spatially lagged dependent variable coefficient estimates are generally within the range of intrastate estimates by previous researchers.

My study also suggests that the strength of spatial dependence differs for experienced and beginning teachers. A 1% increase in the distance-weighted average of experienced teacher salaries in nearby districts increases experienced teacher salaries in a district by about 0.52%, but a 1% increase in the distance-weighted average of beginning teacher salaries in nearby districts increases beginning teacher salaries in a district by roughly 0.66%. Beginning teacher salaries are thus more spatially dependent than are salaries for experienced teachers.

The findings reported in this paper also suggest that failing to account for the spatial dependence in teacher salaries often results in inconsistent estimates for several determinants of teacher salaries. Researchers should be mindful that neighboring school districts affect each other in important ways and thus considering such spatial relationships may help researchers avoid reaching misleading conclusions about a number of important school district outcomes.

Appendix

Computation of Average Marginal Effects

The marginal effects of the exogenous variables in Equation (2) are not equal to the parameters in vector β. Rewriting Equation (2) as:

$$Y = [1 - \rho W_1]^{-1} X\beta + [1 - \rho W_2]^{-1} u, \tag{3}$$

it is clearly evident that the partial derivative of Y with respect to a single exogenous variable $X_k (n \times 1)$ is given by:

$$\frac{\partial Y}{\partial X_k'} = \begin{pmatrix} \frac{\partial Y_1}{\partial X_{1k}} & \frac{\partial Y_1}{\partial X_{2k}} & \cdots & \frac{\partial Y_1}{\partial X_{nk}} \\ \frac{\partial Y_2}{\partial X_{1k}} & \frac{\partial Y_2}{\partial X_{2k}} & \cdots & \frac{\partial Y_2}{\partial X_{nk}} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{\partial Y_n}{\partial X_{1k}} & \frac{\partial Y_n}{\partial X_{2k}} & \cdots & \frac{\partial Y_n}{\partial X_{nk}} \end{pmatrix} = \beta_k [1 - \rho W_1]^{-1}. \tag{4}$$

Therefore, the marginal effect on teacher salaries of an explanatory variable such as union activity is $\beta_k[1 - \rho W_1]^{-1}$. If X_k is measured at the district level, then the *average* marginal effect of an increase in X_k in a district on teacher salaries in that district is equal to β_k times the average of the diagonal elements of the $[1 - \rho W_1]^{-1}$ matrix. More formally, setting

$$A = [1 - \rho W_1]^{-1} = \begin{pmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{pmatrix}, \quad (5)$$

the average marginal effect of an increase in X_k in a district on teacher salaries in that district is $\beta_k 1/n\sum_{j=1}^{n} ajj$. If X_k is measured at a level of concentration larger than the district, such as the state, then the average marginal effect of an increase in X_k at the state level on teacher salaries in a district is equal to $\beta_k 1/n\sum_{j=1}^{n}\sum_{i=1}^{n} d_{ij}a_{ij}$, where d_{ij} is equal to 1 if $i = j$ or if i and j are in the same state and are defined as neighbors according to the spatial weight matrix (that is, within 50 miles of each other, as indicated in this paper). Because X_k is measured at the state level, the marginal effect of X_k on Y for district i includes not only the direct effect of district i but also the indirect effects of "neighboring" districts in the same state. Kim, Phipps, and Anselin (2003) showed that if X_k does not vary among neighboring districts (e.g., the variable is measured at the state level and all neighbors are in the same state), then the average marginal effect of a unit increase in X_k is equal to $\beta_k/1-\rho$. We can think of $1/n\sum_{j=1}^{n}\sum_{i=1}^{n} d_{ij}a_{ij}$ as a *spatial multiplier* with both $1/n\sum_{j=1}^{n} a_{jj}$ and $1/1-\rho$ as special cases.

REFERENCES

Anselin, Luc. 1988. *Spatial Econometrics: Methods and Models.* Dordrecht: Kluwer Academic Publishers.

____, Anil K. Bera, Raymond Florax, and Mann J. Moon. 1996. "Simple Diagnostic Tests for Spatial Dependence." *Regional Science and Urban Economics*, Vol. 26, No. 1, pp. 77–104.

Babcock, Linda C., and John B. Engberg. 1999. "Bargaining Unit Composition and the Returns to Education and Tenure." *Industrial & Labor Relations Review*, Vol. 52, No. 2, pp. 163–78.

____, ____, and Robert T. Greenbaum. 2005. "Wage Spillovers in Public Sector Contract Negotiations: The Importance of Social Comparisons." *Regional Science and Urban Economics*, Vol. 35, No. 4, pp. 395–416.

Ballou, Dale, and Michael Podgursky. 2002. "Returns to Seniority Among Public School Teachers." *Journal of Human Resources*, Vol. 37, No. 4, pp. 892–912.

Baugh, William H., and Joe A. Stone. 1982. "Teachers, Unions, and Wages in the 1970s: Unionism Now Pays." *Industrial & Labor Relations Review*, Vol. 35, No. 3, pp. 368–76.

Booth, Alison L. 1995. *The Economics of the Trade Union.* Cambridge U.K.: Cambridge University Press.

Chambers, Jay G. 1977. "The Impact of Collective Bargaining for Teachers on Resource Allocation in Public School Districts." *Journal of Urban Economics*, Vol. 4, No. 3, pp. 324–39.

Clotfelter, Charles, Elizabeth Glennie, Helen Ladd, and Jacob Vigdor. 2008. "Would Higher Salaries Keep Teachers in High-Poverty Schools? Evidence From a Policy Intervention in North Carolina." *Journal of Public Economics*, Vol. 92, No. 5–6, pp. 1352–70.

Delaney, John T. 1985. "Unionism, Bargaining Spillovers, and Teacher Compensation." In David B. Lipsky, ed., *Advances in Industrial Relations*, Vol. 2, pp. 111–42. Greenwich, CT: JAI Press.

Easton, Todd. 1988. "Bargaining and the Determinants of Teacher Salaries." *Industrial and Labor Relations Review*, Vol. 41, No. 2, pp. 263–78.

Ehrenberg, Ronald G., and Joshua L. Schwarz. 1986. "Public Sector Labor Markets." In Orley C. Ashenfelter and Richard Layard, eds., *Handbook of Labor Economics*, Vol. 2, pp. 1219–68. Amsterdam: North Holland.

Figlio, David N. 1997. "Teacher Salaries and Teacher Quality." *Economic Letters*, Vol. 55, No. 2, pp. 267–71.

______. 2002. "Can Public Schools Buy Better Qualified Teachers?" *Industrial and Labor Relations Review*, Vol. 55, No. 4, pp. 686–99.

Freeman, Richard. B. 1986. "Unionism Comes to the Public Sector." *Journal of Economic Literature*, Vol. 24, No. 1, pp. 41–86.

Gerwin, Donald. 1973. "An Information Processing Model of Salary Determination in a Contour of Suburban School Districts." *American Education Research Journal*, Vol. 10, No. 1, pp. 5–20.

Greenbaum, Robert T. 2002. "A Spatial Study of Teachers' Salaries in Pennsylvania School Districts." *Journal of Labor Research*, Vol. 23, No. 1, pp. 69–86.

Hedrick, David W., Henson, Steven E., Krieg, John M., and Wassell, Jr., Charles S. 2011. "Is There Really a Faculty Union Salary Premium?" *Industrial and Labor Relations Review*, Vol. 64, No. 3, pp. 558–75.

Hirsch, Barry T., and John T. Addison. 1986. *The Economic Analysis of Unions.* Boston: Allen & Unwin.

Holmes, Alexander B. 1976. "Effects of Union Activity on Teachers' Earnings." *Industrial Relations*, Vol. 15, No. 3, pp. 328–32.

Hoxby, Caroline. M. 1996. "How Teachers' Unions Affect Education Production." *Quarterly Journal of Economics*, Vol. 111, No. 3, pp. 671–718.

Kalenkoski, Charlene M., and Donald J. Lacombe. 2008. "Effects of Minimum Wages on Youth Employment:

The Importance of Accounting for Spatial Correlation." *Journal of Labor Research*, Vol. 29, No. 4, pp. 303–17.

Kaufman, Bruce E. 2002. "Models of Union Wage Determination: What Have We Learned Since Dunlop and Ross?" *Industrial Relations*, Vol. 41, No. 1, pp. 110–58.

Kelejian, Harry H., and Ingmar R. Prucha. 1998. "A Generalized Spatial Two-Stage Least Squares Procedure for Estimating a Spatial Autoregressive Model with Autoregressive Disturbances." *Journal of Real Estate Finance and Economics*, Vol. 17, No. 1, pp. 99–121.

Kim, Chong Won, Tim T. Phipps, and Luc Anselin. 2003. "Measuring the Benefits of Air Quality Improvement: A Spatial Hedonic Approach." *Journal of Environmental Economics and Management*, Vol. 45, No. 1, pp. 24–39.

Lentz, Corliss. 1998. "Why Some Communities Pay More than Others? The Example of Illinois Teachers." *Public Administration Review*, Vol. 58, No. 2, pp. 137–44.

LeSage, James P. 1999. "The Theory and Practice of Spatial Econometrics." Unpublished Manuscript.

Lipsky, David B. 1982. "The Effect of Collective Bargaining on Teacher Pay: A Review of the Evidence." *Educational Administration Quarterly*, Vol. 18, No. 1, pp. 14–42.

Lovenheim, Michael F. 2009. "The Effect of Teachers' Unions on Education Production: Evidence from Union Election Certifications in Three Midwestern States." *Journal of Labor Economics*, Vol. 27, No. 4, pp. 525–87.

Martin, Stephanie. 2010. "Are Public School Teacher Salaries Paid Compensating Wage Differentials for Student Racial and Ethnic Characteristics?" *Education Economics*, Vol. 18, No. 3, pp. 349–70.

Martinez-Vazquez, Jorge, and David L. Sjoquist. 1988. "Property Tax Financing, Renting, and the Level of Local Expenditures." *Southern Economic Journal*, Vol. 55, No. 2, pp. 424–31.

Merrifield, John. 1999. "Monopsony Power in the Market for Teachers: Why Teachers Should Support Market-Based Education Reform." *Journal of Labor Research*, Vol. 20, No. 3, pp. 377–91.

Millimet, Daniel L. and Vasudha Rangaprasad. 2007. "Strategic Competition Amongst Public Schools." *Regional Science and Urban Economics*, Vol. 37, No. 2, pp. 199–219.

Moe, Terry M. 2005. "Political Control and the Power of the Agent." *The Journal of Law, Economics, and Organization*, Vol. 22, No. 1, pp. 1–29.

Moran, P.A.P. 1950. "Notes on Continuous Stochastic Phenomena." *Biometrika*, Vol. 37, No. 1–2, pp. 17–33.

Murnane, Richard J., and Randall J. Olsen. 1989. "The Effect of Salaries and Opportunity Costs on Duration in Teaching: Evidence from Michigan." *Review of Economics and Statistics*, Vol. 71, No. 2, pp. 347–52.

______. 1990. "The Effects of Salaries and Opportunity Costs on Length of Stay in Teaching: Evidence from North Carolina." *Journal of Human Resources*, Vol. 25, No. 1, pp. 106–24.

Pencavel, John. 1991. *Labor Markets under Trade Unionism: Employment, Wages, and Hours*. Cambridge, MA: Basil Blackwell.

Ready, Kathryn J., and Marcus H. Sandver. 1993. "Pattern Bargaining in Education." *Education Economics*, Vol. 1, No. 3, pp. 259–66.

Stoddard, Christiana. 2005. "Adjusting Teacher Salaries for the Cost of Living: The Effect on Salary Comparisons and Policy Conclusions." *Economics of Education Review*, Vol. 24, No. 3, pp. 323–39.

Taylor, Lori L. 2010. "Competition and Teacher Pay." *Economic Inquiry*. Vol. 48, No. 3, pp. 603–20.

____, and William J. Fowler, Jr. 2006. "A Comparable Wage Approach to Geographic Cost Adjustment (NCES 2006–321)." Washington, DC: National Center for Education Statistics.

U.S. Census Bureau. 2006a. *State and Local Government Finances Database*. Available at http://www.census.gov/govs/estimate/index.html.

____. 2006b. *State and Local Government Employment and Payroll Database*. Available at http://www.census.gov/govs/apes/index.html.

Vedder, Richard and Joshua Hall. 2000. "Private School Competition and Public School Teacher Salaries." *Journal of Labor Research*, Vol. 21, No. 1, pp. 161–68.

Wagner, Gary A. and Tod S. Porter. 2000. "Location Effects and the Determination of Beginning Teacher Salaries: Evidence from Ohio." *Education Economics*, Vol. 8, No. 2, pp. 109–127.

Walden, Michael L. and Craig M. Newmark. 1995. "Interstate Variation in Teacher Salaries." *Economics of Education Review*, Vol. 14, No. 4, pp. 395–402.

____, and Zulal Sogutlu. 2001. "Determinants of Intrastate Variation in Teacher Salaries." *Economics of Education Review*, Vol. 20, No. 1, pp. 63–70.

Winters, John V. 2009. "Variation in Teacher Salaries in Georgia: Does the Property Tax Base Matter?" *Journal of Education Finance*, Vol. 35, No. 2, pp. 157–71.

Zwerling, Harris L., and Terry Thomason. 1995. "Collective Bargaining and the Determinants of Teachers' Salaries." *Journal of Labor Research*, Vol. 16, No. 4, pp. 467–84.