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The Efficiency of Collective Bargaining in Public Schools

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The Efficiency of Collective Bargaining in Public Schools*

Daniel S. Hosken[†], *David N. Margolis*[‡]

Résumé / Abstract

Résumé :

Nous proposons un modèle de négociations collectives sur les salaires et l'emploi dans le secteur public. La solution de ce modèle implique des équations structurelles de détermination des salaires et d'emploi qui sont estimées à partir de données provenant des conventions colléctives des écoles publiques de l'état de New York. Notre approche a l'avantage d'englober tous les modèles majeurs de la littérature sur les négociations collectives (syndicat monopole, droit à gérer, négociations efficaces et négociations inefficaces) et de relier chaque modèle à une restriction d'égalité sur un ou plusieurs paramètres estimés. Nos résultats suggèrent que l'allocation des ressources spécifiée dans les conventions collectives des enseignants de l'état de New York n'est, en générale, pas efficace. De plus, notre approche nous permet d'estimer le pouvoir de négociationsur les salaires et sur l'emploi séparément. Nous trouvons un pouvoir de négociation sur les salaires de 0.53, et sur l'emploi de 0.71. Finalement, nous démontrons l'importance de contrôler le caractère endogène des salaires lors de l'analyse des flux des services publics dans un marché syndicalisé.

Mots clés : Négociations collectives, contrats efficaces, syndicat du secteur public, éducation

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Abstract :

This paper develops a bargaining model of wage and employment determination for the public sectror. The solution to the model generates structural wage and employment equations that are estimated using data from New York State teacher-school district collective bargaining agreements. An advantage of this approach is that the major collective bargaining models (monopoly union, right to manage, efficient contracting, and inefficient contracting) are nested in the structural equations based on flexible functional forms and these models can be empirically tested as restrictions on estimated model parameters. The empirical results suggest that the allocation of resources generated by collective bargaining in New York State public schools is, by and large, not Pareto efficient. Furthermore, it is possible to estimate separate measures of union bargaining power over wages and employment. Empirically, it appears that union bargaining power over wages is around 0.53, while bargaining power over employment is around 0.71. In addition, the paper demonstrates the importance of controlling for the nature of the collective agreement when measuring the level of public services that flow to a community in the presence of a unionized public sector work force.

Keywords : Collective Bargaining, Efficient Contracting, Public Sector Union, Education

I. Introduction

The goal of this paper is to investigate the impact of economic, social and institutional constraints on public sector negotiations. Using fairly flexible functional forms, we derive a structural simultaneous-equations model of the bargaining process between public sector labor unions and the government in the context of a particular government-provided service, education, while taking into account local education demand factors, institutional constraints, and the teachers' union's bargaining power over wages and employment. There are two major advantages to this approach. First, the structural employment and wage equations nest the four most important collective bargaining models: monopoly union, right to manage, efficient contracting and inefficient contracting[1]. We can thus distinguish empirically between the different approaches by testing hypotheses about estimated parameters. Second, the approach allows measures of union bargaining power to be estimated, and bargaining power over wages and employment can be different, although this is not imposed a priori.

We use data from New York State in 1983, 1986 and 1989 to estimate our models. The empirical results suggest that, given the functional form assumptions of our structural model, collective bargaining between teachers in New York State and their respective school boards generates resource allocations that are neither Pareto efficient nor on the labor demand curve in the vast majority of the cases studied. No school district in New York State negotiated a collective agreement found to lie on the labor demand curve. This result raises serious doubts about the appropriateness of using monopoly union or right to manage models to explain collective bargaining among New York State teachers, and perhaps more generally. Furthermore, we find that for over 80 percent of the school districts in New York State, we can reject the hypothesis that the collective agreement lies on the contract curve (i.e. is Pareto efficient). More generally, we cannot reject the hypothesis that the contract curve is vertical, and thus any efficient contracts would be strongly efficient[2]. Our point estimates, however, suggest a slightly negatively-sloped contract curve when evaluated at the population means.

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[1] Some well-known attempts to distinguish between efficient contracting models and labor demand models (monopoly union and right-to-manage) include Brown and Ashenfelter (1986), MaCurdy and Pencavel (1986) and Abowd (1989). See Farber (1986) for a description of the empirical implications of these approaches to modeling collective bargaining. See Manning (1987) for a description of inefficient contracting and its relation to the other collective bargaining models.

[2] The terminology of strong versus weak efficiency was first introduced by Brown and Ashenfelter (1986).

Our results also suggest that a common fear in studies of collective bargaining in the public sector, namely the risk that the employer does not have a fixed threat point, is justified. Collective agreements in school districts where there is referendum voting on the school budget and where there is the threat of a state-imposed "austerity budget" in the case of disagreement are significantly different from settlements in school districts with no such constraints on spending. In particular, these school boards where the budgets are subject to referendum voting have significantly smaller employment levels than unconstrained boards, whereas the wage settlements, while smaller, are not significantly so.

Lastly, the literature on the economics of education is often concerned with the impact of teacher salaries and staffing levels on the provision of educational services to a community, usually measured as some function of expenditures per pupil. These variables are most frequently taken as exogenous, and the bargaining environment is never explicitly considered in their measurement or instrumentation. We find that the failure to explicitly account for the fact that wages and employment are negotiated in New York State public schools leads to incorrect estimates of the effects of certain community specific characteristics (such as the full value of property and the percentage of minority students) on the level of educational services a community receives and of the influence of certain aspects of the bargaining environment on negotiated contracts.

This paper is structured as follows. Section II presents the questions we address here in more detail and provides empirical and theoretical justifications for the modeling strategy we employ. We then lay out our structural equations and the solution to the system in section III. We specifically choose an objective function for the union that allows for risk aversion and an objective function for the employer (the local school board) that allows it to trade off educational services against taxes and does not impose constant returns to scale a priori. Section IV discusses the empirical implications of our functional forms, both in terms of what they imply about the behavior of both parties and what they suggest for the resource allocation generated by a Nash cooperative bargain. Section V details the econometric specification of the model, including the approximating functions used for the bargaining power parameters[3] and the community preferences. Various specifications of the model are estimated as a system of nonlinear simultaneous equations. After describing the construction of the data set used in the estimations in section VI, we present our empirical results in section VII. Section VIII discusses the implications of controlling for negotiated wages when considering the provision of educational services to a community. Section IX concludes.

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[3] Svejnar (1986) uses a similar approximating function approach in his estimation of bargaining power.

II.a. Collective Bargaining and Public Schools

According to recent estimates, 36.86 percent of public sector workers in the United States are members of a union, and 43.33 percent of U.S. public sector employees are covered by a collective bargaining agreement.[4] Despite this fact, most studies of markets for public goods fail to explicitly account for the fact that both public sector wages and employment are often the outcome of a bargaining process between government and labor. When one considers that there is no universally accepted model of how unions and governments engage in bargaining, this situation seems less puzzling. Not only is there a lack of consensus on how to model bargaining power in general, but among the competing theories that depend on some measure of union "bargaining power", few attempts have been made to estimate this measure in the case of public sector collective bargaining.

One important instance in which collective bargaining is likely to play a major role is the market for publicly provided educational services. Not accounting for the fact that wages and employment are often the outcome of bargaining between a teachers' union and a school district can lead researchers to overstate the level of educational services flowing to a community. For instance, in most analyses of a community's demand for education, authors use total expenditures per pupil as the measure of educational services provided to the community.[5] If the labor market for teacher services were perfectly competitive, all teachers would be paid their marginal products and this would be an appropriate measure. However, in many locations teachers are unionized, and an enormous literature has developed[6] that shows the (generally significant and positive) impact that collective bargaining has on the wages of covered workers. Since teacher compensation takes up the largest share of educational spending, the level of expenditure per pupil is likely to severely overestimate the educational services consumed by a community in unionized school boards.

In order to arrive at a correct measure of educational services consumed in a school district, it is essential to model teacher employment and wage determination. The literature on the modeling of collective bargaining has several suggestions for how to model the results of a collective bargain

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[4] Hirsch and Macpherson (1993). Their estimates are calculated using the 1991 Current Population Survey.

[5] See, for example, Bergstrom et al (1988), Megdal (1984), Bergstrom et al (1982), Conte (1985).

[6] See Lewis (1986) for a survey of several hundred studies of the union-nonunion wage differential published prior to 1984.

between an employer and a union, but there are several problems particular to public sector collective bargaining that do not arise in models that deal with the private sector. First of all, many of these models rely on the presence of a threat point for both the employer and the union in the determination of the equilibrium contract. Unfortunately, in the public sector it is not clear that such a firm threat point exists for the employer. For example, school boards can negotiate contracts with their unions and then fix a millage (property tax) rate according to the negotiated wage bill. This implies the absence of a true "zero profit condition", since (in theory) the school board can set whatever millage rate it finds necessary to cover its costs. There is little direct incentive to "bargain tough" with the unions, and thus wages might be higher than they would otherwise be if there was not this flexible ceiling. Thus if one were to estimate union power based on the wage gains achieved for union members, one might (incorrectly) draw the conclusion that unions in the public sector were stronger than their private sector equivalents just because their bargaining counterparts have less rigid constraints than in the private sector.

There are several factors that might mitigate this argument. First, a standard Tiebout argument would suggest that an excessive tax burden could lead to out-migration and thus a drop in property values and therefore a drop in the tax base. This would, over time, limit the flexibility of the school board to further increase taxes. Second, reelection concerns could cause public sector employers to be wary of raising taxes too brutally, since certain populations might be more sensitive to the tax burden imposed by the school board than to the educational services it provides. Finally, certain institutional factors can serve as constraints on the school board's ability to raise taxes or on the union's ability to force its demands. For instance, in some cases the school board's budget must be subjected to a referendum vote, and too many rejections can lead to an "austerity budget" being imposed from the state level. This sort of constraint could serve to harden the school board's threat point in collective bargaining. It is also the case that, in most states, it is illegal for public sector unions to strike. In New York State, if a teachers' union strikes it can lose the right to collect dues directly from teachers' paychecks, and union members may be fined two days pay for each day on strike.[7]

There have been some attempts to empirically apprehend the question of collective bargaining in the public sector[8]. In particular, Currie (1991) and Eberts and Stone (1986) both develop models of bargaining applied to the market for public school teachers. These papers focus on determining if there is empirical evidence of school districts and teachers' unions engaging in

[7] See the Taylor Act.

[8] Some of the earlier reduced-form tests of competing bargaining models include Brown and Ashenfelter (1986) and MaCurdy and Pencavel(1986). See Pencavel (1990) for a recent review of this literature. See Freeman and Ichniowski (1988) for a set of studies on public sector unions.

efficient contracting; that is, they attempt to determine if the negotiated wage-employment combination lies off of the school districts' labor demand curves and on the contract curve in wage-employment space.[9] Using reduced form specifications, Eberts and Stone find evidence of efficient contracting, while Currie cannot reject the null hypothesis of strongly efficient contracting.

Neither of these papers actually attempts to estimate the ability of the union to appropriate rents for the teachers they represent. Perhaps the best known attempt to estimate union bargaining power (albeit on a small sample of private sector bargaining pairs) comes from Svejnar (1986). He imposes an efficient contract specification and attempts to estimate whether the contract curve and the labor demand curve coincide. In the process, he also uses approximating functions to recover an estimate of the union's bargaining power over employment and wages[10]. In his empirical results, he is unable to reject the hypothesis of a 50-50 split of quasi-rents between the employer and the union, although his point estimates vary wildly and are not constrained to fall between 0 and 1.

II.b. The Two-Stage Approach to Modeling Collective Bargaining

In this paper, we make use of the formalization of collective bargaining proposed by Manning (1987). His is a sequential bargaining model in which the union and employer bargain separately over wages and employment. He considers both the case where the employer and union bargain over employment first and wages second, as well as the opposite case where wages are bargained over first and employment second. He shows that if the bargaining over employment takes place first, the resulting level of employment will always be such that the contract is socially efficient, i.e. the marginal product of labor will be equal to the outside wage at the negotiated employment level. However, when the union and employer bargain over wages first and then over employment, one can observe wage-employment combinations that correspond to monopoly union, right to manage, efficient contracting, or what he calls "inefficient contracting" models, depending upon the bargaining power parameters of the model, which are allowed to differ between the wage and the employment bargain[11]. Inefficient contracting, in the sense suggested by Manning, results from a case in which the union has different bargaining

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[9] See Farber (1986) for a more complete description of these types of bargaining models.

[10] Svejnar (1986) models bargaining power as a linear function of the unemployment rate, the rate of change in inflation, and several indicator variables corresponding to the presence of government-imposed price and wage guidelines and regulations.

[11] Differential bargaining power in a sequential bargain can be shown to be isomorphic with differential union preferences over wages and employment (see Pencavel (1990)). Appendix 1 derives the transformation. However, we believe that once one allows for risk aversion on behalf of the union, the most reasonable interpretation of the model parameters is in terms of differential bargaining power.

powers over both wages and employment, and the resulting contract lies neither on the contract curve nor on the labor demand curve. What makes Manning's paper econometrically useful is that it is based on a structural model that is relatively straightforward to implement empirically, and testing between competing bargaining models reduces to performing statistical tests on estimated parameters.

Although the added flexibility of the Manning model is in itself a desirable property, one might ask whether it is reasonable to assume that wage and employment bargains are distinct, and whether union bargaining power over wages and employment could be different. As a means of justifying his approach, Manning (1987) cites the fact that wage contracts are typically negotiated for fixed durations (usually 1 or 2 years in Britain, 3 years in the United States). On the other hand, the firms that sign these agreements typically see their employment fluctuate throughout the duration of the contract, and not just at renegotiation times. This alone suggests a lack of simultaneity in wage and employment determination. Manning further suggests that the impossibility of complete contingent contracting might make it optimal to fix a wage ex-ante and vary employment as a result of market conditions ex-post. This is particularly likely to be relevant in the case of public education, since students are discrete. Finally, Manning cites other research that suggests that bargaining over wages is separated from bargaining over employment in a hierarchical sense, with wage negotiations taking place at the enterprise level and employment negotiations taking place at the establishment, or even workplace, level. Insofar as the temporal decoupling of wage and employment negotiations is concerned, we feel that the Manning approach is reasonable. For all of these reasons, we feel justified in taking a sequential approach to modeling collective bargaining.

Insofar as the possibility of differential bargaining power is concerned, we feel that this too is a reasonable allowance to make. The distinction between the enterprise level wage bargain and the establishment (or workplace) level employment bargain noted by Manning suggests that better organized workplaces might be able to affect employment decisions more effectively than less well organized workplaces. The presence of last-in, first-out rules found in many union contracts may also make it easier for the union to mobilize support for wage demands (that affect all workers) rather than employment concerns that only affect some workers[12]. In addition, it may be the case that the institutional structure of bargaining may have an effect on the different types of bargaining power. For instance, teachers' contracts in New York State have historically included detailed wage scales, with the level of wages corresponding to the number of years of teaching experience and the highest degree attained by the teacher, while they only specify a range of possible class

[12] See Manning (1987) p. 125.

sizes, such as 20 to 25 students per class. This type of contract suggests that teachers' unions may have more power to fix particular wage rates than to set employment levels. Furthermore, when reading the headlines about the causes of various strikes, one sometimes hears that the last sticking point between management and labor is some aspect of working conditions or staffing rules, after wages have been settled upon. An equal bargaining power assumption would suggest that disagreements are either only over wages (in a strongly efficient framework) or over both wages and working conditions/staffing rules (in a weakly efficient framework). One would need a horizontal contract curve in order to observe a disagreement over just working conditions/staffing rules, and the only efficient contract that could generate such a contract curve would require to union to be infinitely risk averse[13] .

III. Specification of the Structural Model

We begin by assuming, as is common in the literature, that the negotiations between the school district and the teachers' union over the level of wages and the level of employment in the school district are independent of other issues that might be discussed in contract talks, such as teaching materials or support staff[14] . The school district's objective function is supposed to be of the form[15]

$$\gamma L^{\alpha} - \lambda w L \tag{1}$$

In equation (1), γL^{α} is the school district's educational production function, which takes on a Cobb-Douglas form with *a* being returns to scale, *g* being a constant and *L* being the level of employment in the district. $\lambda w L$ is a standard cost constraint, where *w* is the wage rate that the school district must pay its teachers and *l* is a parameter that reflects the school district's aversion to taxes. In this formulation, it is assumed that *g* and *l* are

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13 See Svejnar (1986). It should be noted that most models of strike behavior are concerned exclusively with the wage level, and take the employment level as given (see, for example, Ashenfelter and Johnson (1969), Kennan (1986), Cramton and Tracy (1992)). Our extrapolation here relates to a simple efficient contracting model with imperfect information where the employer's threat point is unknown. Thus the union only proposes wage-employment combinations on the contract curve, and the slope of the contract curve will determine the sources of disagreement.

14 We interpret bargaining over class size as bargaining over employment (conditional on enrollment). Implicitly, this forces us to assume that a school board cannot substitute teachers' aids for regular teachers. However, because in general, teachers' aids must be supervised, this assumption seems reasonable.

15 The objective functions for the school board and the teachers' union have been selected to be as flexible as possible while remaining analytically tractable. Although these specifications are almost surely too simple to capture the complexity of the true objectives of the school board and the teachers' union, they generate estimable structural equations from which much intuition can be drawn.

both functions of community-specific characteristics, such as wealth and enrollment[16], while it is assumed that *a* is invariant across school districts. Note that, although *g* and *l* will not be separately identifiable, the size of *l* relative to *g* will reflect a community's preferences for taxes relative to educational services. Also note that we are not constraining the school district to have constant returns to scale in the production of educational services. A value of *a* such that $0<a<1$ would imply decreasing returns to scale in the production of educational services. Note that this is a necessary condition for the existence of an interior solution to the school board's private maximization problem. $a=1$ would imply constant returns to scale, and $a>1$ corresponds to increasing returns. Although we do not have an a priori for the size of the returns to scale parameter in the production of educational services, we would still anticipate $0<a<1$.

Note that the objective function specified in (1) gets around the debate of how to measure demand for publicly provided education, namely choice between a median voter model and that of Romer and Rosenthal (1979). Regardless of the means by which demand is modeled, we hope to capture community preferences towards educational services relative to taxes via the relation between *g* and *l*. Although somewhat abstract, this approach allows us to have well defined community preferences that will affect the behavior of the school district during bargaining.

The teachers' union's objective function is derived from a union maximizing the expected utility of a member with a utility function of the form $U(w) = w^{\tau}$ [17]. This generates a union objective function of the form

$$L\left(w^{\tau} - x^{\tau}\right), \tag{2}$$

where *x* is the opportunity wage of a union member (teacher). This functional form allows for risk averse ($t < 1$) or risk loving ($t > 1$) preferences on behalf of the union members to be reflected in the objective function of the union negotiators.

The bargaining takes place sequentially in a manner suggested by Manning (1987). In the first stage, the school district and the teachers' union

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[16] The inclusion of enrollment in the γ and λ terms allows one to interpret this specification in terms of student-teacher ratios. If total enrollment were to have no impact on community preferences for education or taxes, but the appropriate production function was written in terms of the number of teachers per student (the inverse of the student-teacher ratio), then enrollment would appear in the γ term as enrollment$^{-\alpha}$. In the empirical work we take a linear approximation to the ratio γ/λ, since it is possible that enrollment will enter the school district's objective by some means other than just class sizes.

[17] See MacDonald and Solow (1982) for details on this approach to deriving union objective functions.

bargain over wages. In the second stage, the two parties bargain over the quantity of labor services that will be provided to the school district[18]. The equilibrium is derived by solving the model by backward induction, beginning with solving for the (second stage) equilibrium employment level conditional on the (first stage) negotiated wage. We then derive the equilibrium wage bargain, given that both parties know how this wage will affect the subsequent employment bargain[19].

Let q be a parameter that describes the relative bargaining power of the union over employment, with $0 \le q \le 1$. The equilibrium employment level (L) conditional on the negotiated wage (w) is found by solving the Nash cooperative bargaining game over employment, which is equivalent to solving (3) below.

$$\max_{L} \left(L\left(w^{\tau} - x^{\tau}\right)\right)^{q} \left(\gamma L^{\alpha} - \lambda w L\right)^{1-q} \qquad (3)$$

After considerable simplification, one can show that the level of L that satisfies the first order condition for an optimum for (3) can be described as in (4) below.

$$L = \left(\frac{\gamma\left(\alpha + q(1-\alpha)\right)}{\lambda w}\right)^{\frac{1}{1-\alpha}} \qquad (4)$$

Given equation (4), it is possible to close the model. This is done by solving the Nash cooperative bargaining game over wages (w) given that the players know how the second stage of the bargaining (over L, as described above) will proceed. This is equivalent to solving (5) below, where the equilibrium function $L(w)$ found in (4) is substituted in for L in equation (5). Let p describe the bargaining power of the union over wages, where $0 \le p \le 1$. Recall that p is not necessarily equal to q.

$$\max_{w}\left(L(w - x)\right)^{p} \left(\gamma L^{\alpha} - \lambda w L\right)^{1-p} \qquad (5)$$

Although upon initial inspection it might appear that equation (5) - with equation (4) substituted in - would be intractable. However, the first-order condition of (5) with respect to w is actually quite simple, and equation (6) below provides the analytic expression for w.

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18 Manning (1987) shows that if the union and school district bargain over employment first and wages second, then the parties will engage in efficient contracting. Since we want to allow for the possibility that the negotiated contract might not be efficient, and since real world evidence points in that direction, we solve the model as if the parties bargain first over wages and then over employment.

19 Our approach, as in Manning (1987), is to treat the bargaining as a one-shot game with zero time discounting between the negotiations over wages and over employment. There are no other explicit dynamics in the model.

$$w = x\left(\frac{\alpha + p(1-\alpha)}{\alpha + p(1-\alpha)(1-\tau)}\right)^{1/\tau} \tag{6}$$

Not surprisingly, the equilibrium wage is an increasing function of *x* and an increasing function of *p* given that the teachers are risk averse or risk neutral and $0 < \alpha < 1$.

Given equation (6) it is possible to solve for the unconditional equilibrium level of employment for the school district by substituting the expression in (6) into equation (4). This expression appears below in (7). As in the case of wages, the equilibrium level of employment is found to be an increasing function of *q* for risk averse or risk neutral workers and $0 < \alpha < 1$. In addition, the model predicts that the equilibrium level of employment will be a decreasing function of the union's bargaining power over wages.

$$L = \left[\left(\frac{\gamma}{\lambda}\right)\frac{a + q(1-\alpha)}{x}\left(\frac{\alpha + p(1-\alpha)}{\alpha + p(1-\alpha)(1-\tau)}\right)^{-1/\tau}\right]^{\frac{1}{1-\alpha}} \tag{7}$$

IV. Implications of the Structural Model

As Manning notes,[20] this framework can represent contracts that correspond to different types of collective bargaining models, depending on the values of the (estimated) parameters *p* and *q*. For example, $p = q$ implies that the school district and teachers' union engage in efficient contracting, i.e. that the negotiated agreement is on the contract curve given by the school district's and teachers' union's preferences. If $q = 0$ and $p > 0$ then the right to manage model will be observed, i.e. the union and employer bargain over wages and then the school district picks a level of employment on the labor demand curve. If $q = 0$ and $p = 1$ then the monopoly union model holds, namely the union sets the wage rate and the school board chooses the employment level, once again on the labor demand curve. Finally, if $p \neq q$ then we will observe inefficient contracting; in other words the school district and teachers' union agree on a wage and employment combination that lies neither on the labor demand curve nor on the contract curve. Typically, employment in this contract will be a function of the negotiated wage (see equation (4) above). Hypothesis tests on the estimated values of *p* and *q* can be treated as direct tests of the different bargaining models.

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[20] See Manning (1987), pp. 126-129 for details.

One can see how the parameter restrictions implied by the various models are translated into wage-employment combinations by examining equations (4), (6) and (7). For example, the two labor demand models (monopoly union and right to manage) impose a zero bargaining power over employment ($q = 0$) on the union. In this case, equation (4) reduces to

$$L = \left(\frac{\gamma\alpha}{\lambda w}\right)^{\frac{1}{1-\alpha}} \tag{8}$$

which is precisely the labor demand curve corresponding to the objective function (1). Similarly, if one continues on to the monopoly union case ($p = 1$), equation (6) gives

$$w = x\left(\frac{1}{1-\tau(1-\alpha)}\right)^{1/\tau}$$

which is the wage rate that would be chosen by solving the monopoly union's problem given the employer's labor demand curve (8).

In efficient contracting models, the wage-employment combination is on the contract curve. With the objective functions in equations (1) and (2), the contract curve can be written as

$$L = \left\{\frac{\lambda w}{\gamma\alpha\tau}\left[\left(\frac{x}{w}\right)^{\tau} - (1-\tau)\right]\right\}^{1/\alpha-1}$$

This contract curve is decreasing for *t*>1, vertical for *t*=1 and increasing for *t* less than, but sufficiently close to, 1.

The parameter restrictions imposed by efficient contracting ($p = q$) translate into wage-employment combinations in the same manner as the labor demand models do. In the case of strongly efficient contracting, the union behaves as if it maximizes the net gain of its employed members. This translates into a union objective function of the form

$$L(w-x)$$

which is the same as if the union's members were risk neutral ($\tau = 1$). By equation (7), this implies that the equilibrium level of employment will be

$$L = \left(\frac{a\gamma}{\lambda x}\right)^{\frac{1}{1-\alpha}} \tag{9}$$

and the negotiated wage will be

$$w = x\left(1 + p\frac{1-\alpha}{\alpha}\right). \quad (10)$$

The employment level in (9) is that which maximizes quasi rents, while the negotiated wage in (10) is the wage that guarantees the union its outside wage plus a share *p* of the quasi rents per worker (quasi rents per worker are $x\left(\frac{1-\alpha}{\alpha}\right)$ when *l* is renormalized to 1).

In the weakly efficient contracting case, the contract curve is not vertical. Our functional forms are sufficiently flexible to handle both upward sloping ($t < 1$) and downward sloping ($t>1$) contract curves. In previous empirical tests[21], a failure to reject the irrelevance of both the inside wage and the outside wage in the employment determination equation was most often interpreted as support for weakly efficient contracts. This was because the test was based on a linear approximation to a general functional form, and significant coefficients on both inside and outside wage terms could be interpreted as rejection of either labor demand or strongly efficient contracts. The authors did not consider the possibility of a wage employment combination that was off of both the labor demand and contract curves. In the context of our model, weak efficiency (via equation (7)) implies

$$L = \left[\left(\frac{\gamma\alpha^{1/\tau}}{\lambda x}\right)\left(\alpha + p(1-\alpha)\right)^{\tau - 1/\tau}\right]^{\frac{1}{1-\alpha}}. \quad (11)$$

and thus the employment level will be a function of both the outside wage and the union's bargaining power. Furthermore, since we do not put constraints on *a* and *t* a priori, the predicted relations between employment and outside wages and between employment and bargaining power are relatively free to vary more-or-less independently of each other[22]. However, the additional structure allows us to estimate the *p* and *q* terms directly, and thus while we can accommodate a broad range of possible contract curves, we can also test

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[21] See, for example, Brown and Ashenfelter (1986), MaCurdy and Pencavel (1986) or Currie (1991).

[22] Specifically, given equation (11), $\frac{\partial L}{\partial x} = -\frac{L}{x(1-\alpha)}$ and $\frac{\partial L}{\partial p} = \frac{L(\tau - 1)}{(\alpha + p(1-\alpha))\tau}$.

Thus even though both derivatives are functions of α, the derivative with respect to *p* has an extra degree of freedom due to the presence of τ.

directly to see if the resource allocation specified in the collective bargaining agreement is on the contract curve[23] .

Since the estimation of (6) and (7) is relatively straightforward, it is possible to obtain direct estimates of the bargaining power of the teachers' union over wages and employment, p and q respectively, and thereby direct tests of the various models of collective bargaining. Of course, one should approach our results forewarned; we are estimating a structural model, and although we have tried to incorporate a maximum level of flexibility in our functional forms (while keeping the system of equations identified), the rejection of any particular experiment may be due to model misspecification as opposed to inappropriateness of the bargaining model.

V. The Econometric Specification of the Model

Although we could have estimated the system of equations (6) and (7) directly, we decided to estimate them in log form, in order to reduce the nonlinearity of the problem at least marginally. After some simple algebraic manipulation and taking logarithms of both sides of (6) and (7), we arrive at our basic estimating equations, (12) and (13) below.

$$\log(w) = \log(x) + \frac{1}{\tau}\left(\log\left(p + \alpha(1-p)\right) - \log\left(\alpha + p(1-\alpha)(1-\tau)\right)\right) \quad (12)$$

$$\log(L) = \left(\frac{1}{1-\alpha}\right)\left\{\begin{array}{l}\log\left(\frac{\gamma}{\lambda}\right) + \log\left(1-(1-q)(1-\alpha)\right) - \\ \left[\log(x) + \frac{1}{\tau}\left(\log\left(p+\alpha(1-p)\right) - \log\left(\alpha + p(1-\alpha)(1-\tau)\right)\right)\right]\end{array}\right\}$$

(13)

Here we are presented with two problems. First, since neither p, q nor γ/λ is directly observable, we need to specify approximating functions to allow us to estimate their values as functions of observable characteristics of the bargaining situation. Secondly, since p and q are bargaining power parameters, whatever functional form we apply must generate predicted p's and q's that lie between 0 and 1. Clearly, there are many functional forms one could apply to the observable characteristics of the bargaining situation that would ensure that this condition is met. In our estimations we used the logistic approximating functions described in (14) and (15) below to impose these constraints.

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[23] Although the system may seem underidentified, the restrictions imposed by equation (6), when estimated as a system of equations, allow us to separately identify the contract curve and the bargaining power parameters.

$$p = \frac{e^{z_1'\delta_1}}{1 + e^{z_1'\delta_1}} \qquad (14)$$

$$q = \frac{e^{z_2'\delta_2}}{1 + e^{z_2'\delta_2}} \qquad (15)$$

Note that these specifications allow for bargaining power over wages and employment to vary across school boards in accordance with the observable characteristics z_1 and z_2. It would also be interesting to allow for unmeasured school district specific heterogeneity somewhere in the system of equations. Unfortunately, the nonlinearity of the functional forms renders most projection-based approaches to controlling for school district specific effects inconsistent. In addition, we are unable to include a set of school district specific indicator variables to account for school district specific fixed effects because the short duration of the panel used (at most 3 years per school district), the construction of certain variables (county specific variables for counties with only one school district) and the nonlinearity of the functional forms make such a specification unidentifiable. Finally, estimating the model using a random effects approach (additive on γ/λ) is unfeasible. One logical approach would seem to include a random effect multiplicative on γ/λ and distributed log normal[24], with distribution $\log(\xi_i) \sim N\left(0, \sqrt{1-\alpha}\right)$, to control for unobserved heterogeneity. In multiplying this through it would seem that we would be simply adding a standard normal disturbance. However, in this case the variance of the random effect is a parameter to be estimated, and it is not clear how to operationalize such a restriction, nor is it clear that such a model would necessarily converge were we able to correctly implement an estimation algorithm. Thus the only manner in which we exploit the panel nature of our data is through the inclusion of nonparametric time effects.

From a reading of the bargaining literature, it is not clear what one should include in the vectors of covariates z_1 and z_2 found in the approximating functions. For example, as noted above, Svejnar (1986) uses a linear function of the unemployment rate, the rate of change in inflation and several indicator variables corresponding to the presence of government-

[24] Note that the nonlinearity of p and q makes many sorts of random effects specifications, where the random effect enters in the expression for p or q, unjustifiable from anything but a technical point of view. For example, we might suppose random effects of the form $p_i = \tilde{p}_i \theta_i$, where θ has a distribution with support between 0 and 1 and sufficient probability close to 1 such that $\mathrm{E}(\log(\theta))$ exists. Aside from the obvious difficulty that this is not a mean-zero random effect, it highly unlikely that the heterogeneity in the population of bargaining power parameters would be well described by such a distribution.

imposed price and wage guidelines and regulations as the determinants of union power. In this paper, union power will be specified as a function of the unemployment rate in the county in which the school district is located, the percentage of workers covered by a collective bargaining agreement in the SMSA in which the school district located[25], a measure of the proportion of individuals in the county that voted for a republican in the last election[26], whether or not the school district is a "city" school district (as defined below), and year dummies. The expected signs on most of these variables are clear. Counties with higher unemployment rates should have unions with lower power, higher union coverage locally may signify greater support for union demands, and counties that are more "republican" may be more concerned with tax considerations and promote regulatory environments that are less sympathetic to unions[27].

A city school district in New York State is different than most other school districts in a potentially important way. The millage (school district-imposed property tax) rate that prevails in city school districts is set by an elected school board, while in non-city school districts the proposed millage rate must be voted on in an annual referendum. A non-city school district can always send a budget that is too generous to the voters to be rejected. A city school district does not have this option. If the referendum is rejected too often, the state imposes an "austerity budget" on the school district. This provides the school board with the equivalent of a credible threat point[28]. Thus it seems plausible that, all else equal, school districts that have annual referendum voting should have estimates of union bargaining power that would appear to be lower than those of teachers' unions in cities. In fact, this institutional characteristic of bargaining in New York State schools will allow us to address the commonly voiced criticism (described in section II.a.) of bargaining models as applied to the public sector.

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[25] For school districts not in an SMSA, the state-wide non-SMSA average level of coverage is used. See Hirsch and Macpherson (1993) for details on how these measures were calculated.

[26] Specifically, we considered elections for public office at the state or national level in which there was statewide voting for the same candidate (governor, attorney general, senator, and president), and calculated the difference between the proportion of the vote that was Republican in the state overall and the proportion of the vote that was Republican in the county in question for a particular election. This measure is used to account for candidate- and election-specific effects in voting patterns.

[27] Historically, in the United States, labor unions have tended to support the Democratic Party over the Republican Party in most elections, and likewise Democratic administrations tend to be more sympathetic to labor concerns than Republican ones (Freeman and Medoff (1984)). Thus we interpret a relatively large share of Republican votes as being related to policies that favor employers relative to unions.

[28] Strictly speaking, if a school district is forced to use an austerity budget, it must meet the terms of a previously negotiated teacher contract. However, by cutting the "non-essential" elements of the budget, such as athletics, extra-curricular activities and support staff, by not providing cost-of-living increases and (to some extent) by enlarging class sizes, the school district can affect the wages and working conditions of teachers.

Finally, since there does not appear to be any consistent way to a priori distinguish factors that are likely to affect bargaining power over wages from factors that are likely to affect bargaining power over employment[29] , the vector of explanatory variables that will be used to identify *p* and *q* will be the same, i.e. $z_1 = z_2$.[30]

As can be seen from equation (13) above, it is impossible to identify both *g* and *l* separately without imposing arbitrary restrictions. However, characteristics related to a community's preferences for education and taxes should be likely to determine both *g* and *l*. Thus, *g* and *l* will be modeled with the approximating function

$$\log\left(\frac{\gamma}{\lambda}\right) = c'\beta \qquad (16)$$

In (16), *c* is a vector of community characteristics likely to affect the demand for education and distaste for taxes and year dummies and *b* is a coefficient vector. As suggested in the literature on the demand for education, a community’s demand for education is likely to be a function of the number of students in the district and expected growth in enrollment, its wealth (as proxied by the full value of property in the district), teacher quality (as proxied by the opportunity wage that the school district’s teachers can expect on the job market) and characteristics that describe the socio-economic composition of the community, e.g. percentage of minority students, percentage of students on welfare, etc. Some of these factors (percentage of students on welfare and school district wealth in particular) might also be related to preferences concerning taxes, as would other community-specific characteristics, such as the strength of the republican vote and variable that might be subsumed into an SMSA-specific effect.

VI. Data

The data used in this study come from three different academic years, 1983-84, 1986-7, and 1989-90 and six different data sets. We restrict our attention to all school boards for which we could locate a collective bargaining

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[29] In New York State, school boards can not finance their budgets with debt. Even if this were the case, we could assume that the manner in which public education is financed, e.g. via increases in the millage rate or debt issues, does not directly affect the bargaining power of the parties, although it might enter into the community preferences via an SMSA-specific effect.

[30] We exploit the structure of equations (12) and (13) in order to identify all of the relevant parameters of both δ vectors.

agreement in the five-year period preceding 1983, which left us with 597 school districts. Since almost all New York State teachers' union contracts are negotiated every two or three years, we chose to examine wages and employment at three year intervals in order to ensure that each wage-employment pair we observe corresponds to a different collective bargaining agreement. Thus the final sample consisted of 1491 school district-years.[31]

The school district wage used in this analysis is defined to be the average annual earnings from teaching in a school district, according to the collective agreement, divided by 40.[32] The average annual earnings are divided by 40 in order to account for the fact that a typical New York State teacher is required to work 200 days a year, and thus this gives a measure of weekly contractual earnings. Thus the opportunity wage, *x*, and the negotiated wage, *w*, calculated in this manner are comparable in terms of time scale[33]. The contractual wage information, in addition to the average age, mean educational attainment and proportion of the teaching staff that is female in a school district come from the New York State Department of Education's Personnel Master File. The Personnel Master File has a great deal of information from the personnel records of all New York State public school teachers starting in 1977 and continuing to the present.

The information about the non-financial characteristics of a school district comes from the New York State Department of Education's Basic Educational data set. The variables drawn from this data set include: enrollment in the school district, a measure of the expected change in enrollment[34], percentage of minority students in the school district and percentage of children on welfare in the school district. The information about the wealth of a school district (the full value of property per pupil) and the information about whether or not the school district is a city school district

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[31] We use an unbalanced panel of school districts and suppose that the process that determines missing data years for a given school district is independent of the wage and employment determination processes.

[32] Since the composition of the teaching staff may be a choice variable of the school district, taking the average annual wage of teachers in a school district as our negotiated wage leaves us open to the possibility that the composition of teaching staff might be strategically manipulated by the school board. However, since our alternative wage measure also accounts for the composition of the workforce, the problem becomes less serious. Furthermore, since we only model negotiations over a single "wage", since the employment level times this wage is interpreted as the total wage bill, and since we do not impose constant returns to scale a priori, the correct measure for the "wage" is an average compensation cost measure, averaged over total teacher employment.

[33] Opportunity wages were also calculated on a weekly basis.

[34] Future change in enrollment in year t is defined to be: $\frac{\left(\text{Enrollment}_{t+3} - \text{Enrollment}_{t}\right)}{\left(\text{Enrollment}_{t}\right)}$

comes from the New York State school district financial files. The county unemployment rate and proportion of the Republican vote in a county comes from the *New York State Statistical Year Book*. Finally, the union coverage data was kindly provided by Barry Hirsch and corresponds to the data presented in Hirsch and Macpherson (1993). Their calculations are based on information found in the Current Population Survey.

The opportunity wage (x) is calculated using a two-step process[35]. In the first stage an earnings equation is estimated using data from a cross-section of working adults found in the NBERs outgoing rotation group subsample of the Current Population Survey. The log of usual weekly earnings is estimated to be a function of sex, age, age squared, educational attainment,[36] whether or not the individual lives in an SMSA, and a set of year indicators.[37] In the second stage, the log of the opportunity wage is imputed by taking the average levels of the explanatory variables for teachers in each school district and multiplying them by the estimated coefficients from the first-stage.

Descriptive statistics for all of the variables used in the estimation of the bargaining and the educational services models appear in Table 1.

VII. Results

We estimated the structural models in equations (12) and (13) according to several methods. In all cases we added normally-distributed i.i.d. additive errors to equations (12) and (13), allowing for cross-equation covariance in the additive errors. We estimate the system of equations by nonlinear least squares under several maintained hypotheses. In addition to the unconstrained specification described in section V, we estimated the system imposing q=0 (the maintained hypothesis corresponding to labor demand models) and imposing $\delta_1 = \delta_2$, thereby imposing p=q (the maintained hypothesis corresponding to efficient contracting models). For each of these

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[35] In addition to our derived opportunity wage, we also used the average wage in the county in which the school district was located and the average wage in all other school districts in the county as alternative measures of the opportunity wage. In the vast majority of cases, structural models using the county-average ex-district teacher wage did not converge, while those using the average county wage yielded results very similar to those presented below.

[36] Educational attainment is measured as a set of indicator variables corresponding to varying degrees of attainment; that is primary school, more than primary school but less than high school, high school, more than high school but less than 4-year college, 4-year college, more than 4-year college but less than masters, and masters and beyond.

[37] The results of this earnings equation are presented in appendix B. These models were estimated with and without corrections for self-selection. The results presented below use the selection bias-corrected alternative wages.

maintained hypotheses, we also constrained the union members to be risk neutral (t=1). Thus, if p is estimated to be equal to q (in either the unconstrained or the p=q case), this implies that the efficient contract will be strongly efficient.

To give a point of reference, we first present a series of estimates of a linear approximation model for employment determination. These models include the inside wage, the outside wage[38] and all of the regressors appearing in the z_1, z_2 and c vectors and three different measures of the outside wage by OLS. We also estimate the linear model instrumenting for the inside wage. We then present our estimates of the system of equations (12) and (13) with the various parameter restrictions. We show what these estimates imply for the average levels of bargaining power over wages and employment, and construct several tests of the hypotheses suggested by the labor demand and efficient contracting models. We then discuss briefly the interpretation of the estimated parameters of the $\frac{\gamma}{\lambda}$ function.

VII.A. Linear Approximation Results

For the sake of comparison with existing approaches to modeling public sector bargaining and with our estimates of the structural models, we estimated a series of linear employment determination models. These results can be interpreted as first-order approximations to a general employment determination model and are presented in table 2. The first 3 specifications represent ordinary least squares estimates of the relation between negotiated wages, outside wages and employment. They differ only in their definition of outside wages: computed based on the human capital model described at the end of section IV (OLS1), measured as the average wage in the county (OLS2) or measured, as suggested by Currie (1991) as the average wage in other school districts in the same county (OLS3). In the fourth specification (IV) we instrumented the current negotiated wage with the previous negotiated wage and a year effect indicator. Although this approach required us to eliminate all school districts with only one observation for lack of a previously negotiated wage, as well as the first observation from every school district with more than one observation (for the same reasons), it is consistent with the idea (presupposed in the efficient contracting model) that employment and earnings are simultaneously determined.

[38] For comparison purposes, we estimate the OLS specification with three different measures of the outside wage: our human capital regression predicted wage, the average wage in the county in which the school district is located, and the average wage in all other school districts in the county (the measure used by Currie (1991)).

A naive interpretation of the results of such models is the following. If labor demand models are appropriate, the outside wage should be insignificant in the employment determination decision, since all of the relevant information is already contained in the inside wage. Furthermore, the labor demand model implies that, under normal circumstances, the relation between inside wages and employment should be negative. On the other hand, the strongly efficient contracting model as defined by Brown and Ashenfelter (1986) suggests that employment is fixed based on the outside wage alone, and thus the inside wage should be insignificant in these regressions. It also suggests that, under standard assumptions, the relation between employment and the outside wage should be negative. Both of the remaining alternatives (weakly efficient contracting and Manning's "inefficient contracting") are more flexible characterizations, in that they make no a priori predictions about covariances between observables. One distinction is that weakly efficient contracting supposes that the wage-employment pair is nonetheless on an (unobservable) contract curve that could theoretically be derived if one knew the correct objective functions of that bargaining parties. Inefficient contracting, on the other hand, implies that the negotiated agreement can be found somewhere off the contract curve determined by the two parties' objective functions, but since this is a measure zero set in wage-employment space for most normal objective functions, this characterization has little empirically testable content. Nevertheless, neither the weakly efficient or inefficient contracting approach to modeling collective bargaining implies testable restrictions on the coefficients on inside wages or outside wages in a linear employment determination equation.

The results in table 2 are consistent with neither labor demand nor strongly efficient contracting models. In all four specifications we find a significant *positive* relation between the log of the inside wage and the log of employment. This is only possible under some form of collective bargaining other than labor demand or strong efficiency. Furthermore, although the outside wage enters significant and negative (as necessary for strong efficiency) in OLS specifications 2 and 3, the relation is insignificant when one uses a human capital approach to measuring outside wages, and the relation is positive and insignificant once we instrument the inside wage. These results suggest that the most appropriate model for collective bargaining in public schools in New York is either weakly efficient contracting with an upward-sloping contracting curve or inefficient contracting. In any case, in our structural estimates, we should not expect to estimate q=0 (labor demand models) or p=q and t=1 (strongly efficient contracting models).

Several other coefficients in these regressions are suggestive for what we should expect in the structural models, and are consistent with our expectations. For example, city is always positive and significant. This suggests that the fear expressed earlier, namely that public sector unions might appear stronger than their private sector equivalents, is at least somewhat justified. Those school districts in which the budget is subjected to a referendum vote (the non-city school districts) have significantly lower employment levels than city school districts. Note that this effect is present even when one controls for whether or not the school district is located in an SMSA.

Interestingly, the republican vote is also consistently positive, although significant only in the instrumental variables specification. This suggests that more republican school districts tend to prefer higher employment levels. Of course, given the reduced-form nature of the models being estimated, we cannot directly draw conclusions about the implications of being in a republican school district for bargaining power or for community preferences, since the two effects are confounded in a single coefficient in the linear approximation approach. However, this might suggest that there is a positive relation between the republican vote and union bargaining power over employment that is sufficiently strong to overwhelm the expected negative relation between the republican vote and community distaste for taxes.

Finally, the county unemployment rate enters negative and significant in the OLS models (and significant at the 90 percent level in the IV model). Union coverage has no significant effect, while larger school districts (as measured both by enrollment and the number of schools) have more teachers (as expected) and school districts with more minority students tend to have fewer teachers.

VII.B. Estimates from the Structural Models

The nonlinear OLS estimates of the parameters from equations (12) and (13) appear in Table 3. Results from three different specifications of the model are presented. In the first specification, we forced *q* to be equal to zero. This is equivalent to imposing a labor demand model on the data. If the estimated *p* is not significantly different from one, we have the monopoly union model, otherwise we have the "right to manage" model. In both of these models the union has no bargaining power over employment. In the second specification we constrained the coefficients on the vectors that determine bargaining power of wages and employment to be the same $(\delta_1 = \delta_2)$, which corresponds to the case where the union's power over wages and employment are equal, or the efficient contracting framework. Finally, in our third specification we allow all coefficients in the *d* vectors to vary freely, thus allowing the union differential bargaining power over wages and employment. Under this specification, all of the other bargaining models can be reduced to constraints of the estimated parameters, and these hypotheses can be econometrically tested. Each of these three specifications is estimated both with and without the constraint t=1, i.e. that the members of the union are risk neutral (or that any efficient contract will be strongly efficient). Table 4 presents the mean and standard deviation over the pooled sample of the values of p and q implied by each of the three specifications.

There are many interesting aspects to the results. First, as one might expect, convergence was more rapid when we imposed the t=1 constraint (at most 7 iterations) than when we allowed t to be free (between 38 and 47 iterations). Although the results are dramatically different between the specifications where we constrain q=0 and the specifications with p=q and p and q free, the imposition of the various constraints does not seem to have a dramatic impact on the explanatory power of the model. In particular, even though the models estimated under the assumption p=q are closer to the unconstrained models than those estimated under the assumption q=0, the q=0 explain the data marginally better.

In the cases where the point estimate of t is close to 1 (p and q free and q=0), the imposition of this constraint does not have much impact on the results. On the other hand, in the model where this constraint bears some theoretical weight (p=q), the point estimate is significantly different from 1, and imposing strongly efficient contracting (i.e. imposing t=1) changes the results fairly dramatically. Although the point estimate of t is positive in the p and q free specification , suggesting an downward-sloping contract curve (see section IV), a value of t less than, but close to, 1 is certainly within a 95% confidence interval. Still, for the efficient contract (p=q) results, t<1 is far outside a 95% confidence band. Recall that the linear approximation results suggested that, if an efficient contracting framework was appropriate, it would be necessary to have a positive relation between the negotiated wage and employment levels, and thereby and upward-sloping contract curve. Our estimates of t provide the first indices that perhaps efficient contracting is not the appropriate framework for modeling collective bargaining in New York State public schools.

With respect to the determinants of bargaining power, we find much of what is expected in the least constrained specification (column 6, p and q free, t free). A higher level of unemployment has a significantly negative impact on the bargaining power of the union, both over wages and employment. This could be proxying for general economic conditions in the county, or could be the result of another commonly cited mechanism, namely the idea that a looser labor market (more unemployment) means that striking workers can be more easily replaced, thereby reducing their bargaining power[39] . We also find that

[39] Since teacher certification requirements are quite loose in New York State, certification considerations are not likely to have much impact on the ease of replacement of striking teachers.

a higher rate of union coverage increases the union's bargaining power, although this effect is not significant for bargaining power over wages, and is only significant at the 10% level for bargaining power over employment. It should be noted, however, that whenever coverage is significant in the other specifications, it has a positive impact on bargaining power.

The coefficient corresponding to whether a school district is a city school district is positive and statistically significant in the p and q free specifications for bargaining power over employment. It has an insignificant impact on the bargaining power over wages in the unrestricted specifications, although its impact is significant and positive in the $p=q$, $t=1$ specification and is (surprisingly) negative in the $q=0$ specifications. These results are consistent in that, given the downward-sloping labor demand curve suggested by (1) and the estimated $a<1$, a negative coefficient implies that a non-city school board has more bargaining power, and thus gets a higher wage and a lower employment level. The unrestricted results imply that non-city school boards have lower employment levels and (insignificantly) higher wage rates.

This result is consistent with the idea that the institutional constraint of referendum voting imposes a credible threat point on the school board, at least insofar as concerns staffing levels. To further investigate this possibility, we analyzed the city and non-city schools separately (results not shown). We find that whereas most of the expected results hold for the non-city schools (where the threat point is solid), some unexpected results are found for the city school sample. For example, we find a statistically significant negative effect of contract coverage on bargaining power over wages (-0.026 with standard error 0.012) and no effect at all for unemployment on the bargaining power (t=-0.56 in the p approximating equation and t=-1.19 in the q approximating equation). This is further evidence that the presence of a firm threat point is an important prerequisite to applying most contracting models.

We also find that when a school district is located in an area that tends to vote republican more often than the statewide average, the teachers' union has less bargaining power over wages and more bargaining power over employment. This result holds, with varying degrees of significance, for all specifications of structural model we estimated. Note that the result concerning bargaining power over employment is consistent with our linear approximation results.

Finally, we find that union power over wages and employment is significantly greater in 1986 relative to 1983 in almost all specifications, while it is significantly greater over employment in the least constrained specifications in 1989 than in 1983. The 1989 results concerning bargaining power over wages are less clear, except that in the $q=0$ specifications the unions seem to have been stronger than in 1983. These results seem more-or-less consistent with fluctuations in the economy of New York State during this time period.

VII.C. Implications for Bargaining Power and Bargaining Models

Our results concerning the point estimate of t in the p=q model and the fact that certain covariates (such as city/non-city, the proportion of the republican vote and the 1989 indicator variable) affect bargaining power of wages and employment in opposite directions in the least constrained models suggests that the efficient contracting models may not be the most appropriate for collective bargaining in New York State public schools. The fact that the results in the q=0 specification are, in general, significantly different from the results for bargaining power over wages in the corresponding p and q free specifications suggests that labor demand models may not be appropriate either. In this section, we investigate these alternatives more closely using the results from the two p and q free models.

As a first approach, we test for the equivalence of the elements of δ_1 and δ_2. A chi-square test (6 degrees of freedom) gives $\chi^2(6) = 28.210$ when t is free and $\chi^2(6) = 38.417$ when t is constraint to be equal to 1. This suggests that the fitted values of p and q might not be identical. As Manning notes, when p is different from q, unions and school districts are not engaging in Pareto efficient contracting, since the resulting agreement lies off of the contract curve.

In order to develop a sense of what the results in table 3 imply about the levels of union bargaining power over wages and employment, table 4 contains the means and standard deviations of fitted values of p and q, averaged over the population and evaluated under the different specifications of the model[40]. Here we see that, on average, imposing the t=1 constraint does not seem to change the fitted values of p or q very much. Still, there are differences in the average values of p and q according to the model estimated, with the p=q model generating the smallest average fitted values for p and the q=0 model generating the largest. It should also be noted that bargaining power over employment, when estimated separately, is always estimated to be higher than bargaining power over wages. In addition, it is interesting to note that the estimates of bargaining power over wages are all within 2 standard deviations

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40 The values of p and q are calculated as specified in equations (14) and (15). These results are useful for developing intuition, whereas in the next paragraph we construct actual hypothesis tests of the various models.

of 0.5[41] , and are farther than 2 standard deviations from 0. This suggests that, although teachers are not paid their marginal product, there does not appear to be evidence that unions have complete control over their school boards.

The mean estimated *p* under the *q*=0 specifications strongly suggests that the hypothesis of a monopoly union model (which implies $p = 1$) should be rejected. This is further reinforced by the unrestricted specifications, where the mean estimated *q* is, in both cases, more than 6 standard deviations away from zero. This implies that both sorts of labor demand model (monopoly union and right to manage) are inappropriate in the case of teacher bargaining in New York State. On the other hand, in the unrestricted models the difference between the mean *p* and *q* is smaller than the sum of the population standard deviations, suggesting that they might not, in reality, be significantly different from each other. We need, however, to be careful when interpreting results based on averages over the population, since Manning's theory about contract efficiency concerns equivalence of *p* and *q* at a bargaining unit level, and not over the population as a whole.

Note that comparison of the mean fitted values of *p* and *q* in the unrestricted case suggests that although we rejected the very strong hypothesis that $\delta_1 = \delta_2$, we may not be able to reject the hypothesis that $p = q$. Given that this is a structural model and that rejection of efficient contracting could arise because of misspecified objective functions even if this was the true bargaining framework, one would like to see for what share of the school districts in our sample would we be able (or unable) to reject the hypothesis that implies efficient contracting. To answer this question, we constructed tests of the efficient contracting hypothesis $p = q$, as well as the hypothesis underlying the labor demand models $(q = 0)$, at the school district level. We first calculated the fitted values of *p* and *q* and the variance-covariance matrix of *p* and *q* for each school district, evaluated at the mean levels of the exogenous variables school district by school district and making use of the variance-covariance matrix of the model parameters estimated in the unrestricted specifications[42]. Using this information, we first tested the hypothesis $q = 0$. These results are shown in panel A of table 5. Clearly, this approach to modeling collective bargaining is inappropriate to the case of school teachers. In fact, the lowest t-statistic for the entire sample is 3.858 when *t* is unconstrained and 5.288 when *t*=1, and thus we are able to reject the labor demand models for every one of the school districts in our sample at the

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41 Svejnar (1986) failed to reject the hypothesis that union bargaining power was equal to 0.5 in his private sector data set as well.

42 We applied the delta method to get a consistent estimator of the variance-covariance matrix of the estimated *p* and *q*.

99 percent confidence level. It seems unlikely, even given the possibility of misspecification of the objectives, that we would find such a resounding rejection of labor demand models if they were in fact the appropriate way to model collective bargaining in New York State public schools.

We next examined the relation between the estimated p and q values on a school district by school district basis. These results can be found in panel B of table 5. First of all, we found that the correlation coefficient between the fitted p and q values was 0.620 when t is unconstrained and 0.685 when t=1. Given that there were some coefficients in the p and q approximating equations were of opposite sign, the lack of a higher degree of correlation is not surprising. Furthermore, when we directly tested the hypothesis that $p = q$, we were able to reject this hypothesis for 82.6% percent of the school boards in our sample at the 95 percent level when t is freely estimated, 86.4% when t=1. By reducing the confidence interval to 90 percent we were only able to reject an additional 0.2% (0.7%) of the school boards. These results are not particularly encouraging for efficient contracting models. Although they may be due to misspecification of the objective functions in equations (1) and (2), it seems unlikely that, given the relatively general objective functions chosen, we should reject the necessary condition for efficient contracting models so often if the resource allocation generated by collective bargaining agreements in New York State public schools was, in fact, Pareto efficient.

VII.D. Other Results from the Structural Models

The empirical results concerning community demands for education/distaste for taxes, i.e. $\log\left(\frac{\gamma}{\lambda}\right)$, appear to be consistent with results found elsewhere in the literature. For example, wealthier school districts and school districts with larger enrollments appear to demand more educational services, regardless of the assumptions that one makes on the manner in which bargaining is carried out. Furthermore, and also independent of the hypotheses maintained during the estimation, we find that communities appear to demand more education in school districts in which teachers have higher outside wages. This suggests that we are indeed capturing some measure of human capital with our outside wage measure, and that teachers who have characteristics highly valued by the job market also tend to be highly valued by taxpayers of their employing school districts. We find no significant relation, regardless of estimation method, between the share of students on welfare, the share of minority students or the location in an SMSA on community preferences for educational services or taxes. Similar results concerning the demand for teachers have been found elsewhere in the literature[43], so this result may be unrelated to our particular estimation methodology. There could be many offsetting explanations for these non-results, including different taxation schemes in areas where single-family housing is predominant or direct transfers from the state or federal governments to school boards with disproportionate shares of non-white or welfare-dependent students.

One surprising result is that school districts that expect future growth appear to value current educational services significantly less than school districts that will be experiencing zero or negative enrollment growth. This coefficient is significant in general at the 90% level, regardless of the estimation method. Since future enrollment in public schools is fairly easy to predict by looking at current enrollment, the existing stock of preschool children and number of finishing high school students, it is unlikely that this result is due to irrational expectations. Since future enrollment growth was positive on average over the 3 sample years, one interpretation of this result might be that the enrollment growth was unevenly distributed across school districts, with the school districts whose residents dislike taxes the most experiencing the fastest growth. Another potential interpretation might be based on the idea that school boards optimize dynamically under perceived fixed budget constraints[44], and thus the anticipation of spending in the future (tied to enrollment growth) might be offset by a reduction in current spending.

Finally, it seems interesting that although unions in more "republican" school districts have higher bargaining power over employment, community preferences for taxes are as expected. Under all of the sets of maintained hypotheses (except p=q, t=1), the share of the republican vote above the statewide average is significantly negatively related to γ/λ at the 90% level at worst, i.e. more republican school districts like taxes less. Apparently, the negative relation between the republican vote and community preferences is not large enough to offset the positive relation between the republican vote and bargaining power over employment in the linear approximation results. Still, our results seem consistent with the stereotype that more republican communities seem to dislike school taxes significantly more than their less republican counterparts.

The estimate of returns to scale in education (a) is safely in the bounds necessary to obtain an interior solution to the theoretical model, and does appear to be fairly robust to the specification of the model. Using the estimate of a it is possible to calculate the elasticity of employment with respect to

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43 See, for example, Bergstrom et. al (1982).

44 We have taken a static approach to modeling the collective bargaining, and thus this explanation is not perfectly consistent with our modeling strategy.

enrollment and school district wealth (as measured by the full value of property per pupil). This is done by multiplying the estimated coefficient by $\frac{1}{1-a}$, where a is the estimate of a. For the least restricted case (p, q and t free), the estimated elasticities of employment with respect to enrollment and wealth are 0.900 and 0.048 respectively. The estimated employment elasticity with respect to enrollment is not far from that found in Currie (1991), whose estimates are around 0.7. This similarity in the elasticity estimates is reassuring, in that it indicates that our structural approach to the econometric modeling, in addition to allowing us to analyze more interesting aspects of the model estimated, does not yield basic results outside the bounds of previous research.

VIII. Measurement of Educational Services Provided

As mentioned in section II, using expenditures per pupil as the measure of educational services provided to a community may not be correct because the level of employment and wage in a school district are outcomes of the bargaining process between the union and the school district. To examine how serious a problem this might pose to studies that attempt to model a community's demand for education, we ran a simple test based on two different measures of expenditure per pupil[45]. The first is the observed teacher expenditures in a school district per pupil $\left(\frac{Lw}{\text{Enrollment}}\right)$. The second is the "true value" of teacher services to the district per pupil, i.e. expenditures on teachers less the rent captured by the teachers' union $\left(\frac{Lx}{\text{Enrollment}}\right)$. The two measures have a simple correlation of 0.905. This is not surprising, given the significance of the outside wage in the community preference approximating function described in section VII.c. above. However, one should still be wary, since this high correlation does not imply that the size of the rent captured is uncorrelated with other covariates that may be of interest.

In table 6, estimates from two specifications of a "typical" educational demand function are presented using the uncorrected and corrected measures of educational services per pupil. While the choice of the measure of expenditure per pupil does not cause the signs of coefficients to change, it does have a significant effect on the estimated magnitude of the coefficients. For example,

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[45] Our measure of expenditure per pupil is not directly comparable with that found elsewhere in the literature, in that we use only teaching expenditure per pupil and not the total expenditure per pupil as our measure. However, the results obtained are still meaningful, since teaching expenditures make up the largest component of educational expenditures.

moving from model 3 to model 4 we see the estimated wealth elasticity fall by 0.023, or roughly 25 percent. The proportion of minority students and the proportion of students on welfare, which seem to have a significant impact on educational services rendered, are shown to be not significant when one removes the rent-capture component from teacher wages. Further, in the model where the log of uncorrected measure is used it appears that changes in future enrollment have an effect on current expenditures. When the corrected measure is used, one observes no significant effect. Thus, it seems clear that one should account for the endogenous nature of teacher salaries when measuring expenditures per pupil. The failure to do so may yield misleading estimates of education demand function parameters.

IX. Conclusion

In this paper, we developed a model of sequential bargaining over wages and employment in the public sector. This model yielded structural employment and wage equations that were then estimated using data from a sample of New York State teachers' unions. We were able to estimate union bargaining power over wages and employment under the constraints of several theoretical paradigms and in a relatively unconstrained manner. Estimated union bargaining power varies with the bargaining model applied (monopoly union/right to manage, efficient contracting or inefficient contracting) and with the assumptions made about risk preferences, but in the least constrained case we estimate an average bargaining power over wages of around 0.53 and an average bargaining power over employment of around 0.71. The results of our structural model suggest that New York State's teachers' unions and school districts do not engage in monopoly union or right to manage style bargaining, nor does the vast majority of them engage in any sort of efficient contracting. These results are confirmed by a series of linear approximations, which suggest that the outcomes of collective bargaining agreements in New York State public schools are indeed Pareto inefficient. Finally, we find that one should worry about the solidity of the employer's threat point when modeling collective bargaining in the public sector, as unions operating in school boards that have to put their budgets up for a referendum vote by the community tend to have significantly lower bargaining power than their counterparts in which the budget is implemented without being subject to public approval.

Even contingent on the standard caveats about the risks of misspecification error in structural modeling, the results of this paper should not be viewed as being limited to a bargaining context. In fact, this paper has much to offer those interested in the factors affecting a community's demand for education. As noted above, the level of wages and employment of teachers in a school district is not something that is determined in a competitive market, but rather as the outcome of a bargaining process. In order to correctly measure the level of educational services a school district consumes, it is essential to account for the fact that wages and employment are endogenous. Our estimation method offers a manner in which to approach this problem, which is central to much of the research in the economics of education.

References

Abowd, John M. "The Effect of Wage Bargaining on the Stock Market Value of the Firm," *American Economic Review*, September 1989.

Ashenfelter, Orley and George Johnson, "Bargaining Theory, Trade Unions, and Industrial Strike Activity," *American Economic Review*, March 1969.

Bergstrom , Theodore, Judith Roberts, Daniel Rubinfeld and Perry Shapiro. "A Test for Efficiency in the Supply of Public Education," *Journal of Public Economics*, 1988, pp. 289-307

Bergstrom, Theodore, Daniel Rubinfeld and Perry Shapiro. "Micro-Based Estimates of Demand Functions for Local School Expenditures," *Econometrica*, 1982, pp. 1183-1205

Brown, James and Orley Ashenfelter. "Testing the Efficiency of Employment Contracts," *Journal of Political Economy*, 1986, pp. S40-S87

Conte, Michael. "Do Wealth Neutralizing Grants Neutralize the Effects of Wealth?" *The Review of Economics and Statistics*, 1985, pp. 508-513.

Cramton, Peter and Joseph Tracy, "Strikes and Holdouts in Wage Bargaining," *American Economic Review*, 1992.

Currie, Janet. "Employment Determination in a Unionized Public-Sector Labor Market: The Case of Ontario's Teachers," *Journal of Labor Economics*, 1991, pp. 45-65.

Eberts, Randall and Joe Stone. "On the Contract Curve: A Test of Alternative Models of Collective Bargaining," *Journal of Labor Economics*, 1986, pp. 66-81.

Farber, Henry S. "The Analysis of Union Behavior," in Ashenfelter, O. and R. Layard (eds.) *The Handbook of Labor Economics*, Volume 2, (Amsterdam: North-Holland), 1986.

Freeman, Richard B. and Casey Ichniowski, *When Public Sector Workers Unionize*, (Chicago: University of Chicago Press), 1988.

Freeman, Richard B. and James L. Medoff. *What Do Unions Do?*, (New York: Basic Books), 1984.

Hirsch, Barry and David Macpherson. "Union Membership and Coverage Files From the Current Population Surveys: Note," *Industrial and Labor Relations Review*, 1993, pp. 574-578.

Kennan, John, "The Economics of Strikes," in Ashenfelter, O. and R. Layard (eds.) *The Handbook of Labor Economics*, Volume 2, (Amsterdam: North-Holland), 1986.

Lewis, H. Gregg, *Union Relative Wage Effects: A Survey*, (Chicago: University of Chicago Press), 1986.

MacDonald, Ian M. and Robert Solow. "Wage Bargaining and Employment," *American Economic Review*, 1981, pp. 896-908.

MaCurdy, Thomas E. and John Pencavel. "Testing Between Competing Models of Wage and Employment Determination in Unionized Markets," *Journal of Political Economy*, 1986, pp. S3-S39.

Manning, Alan. "An Integration of Trade Union Models in a Sequential Bargaining Framework," *Economic Journal*, 1987, pp. 121-139.

Megdal, Sharon. "A Model of Local Demand for Education," *Journal of Urban Economics*, 1984, pp. 13-30.

Pencavel, John. *Labor Economics Under Trade Unionism*, (Cambridge: Basil Blackwell), 1991.

Romer, Thomas and Thomas Rosenthal. "'Bureaucrats Versus Voters' on the Political Economy of Resource Allocation by Direct Democracy," *Quarterly Journal of Economics*, 1979, pp. 563-587.

Svejnar, Jan. "Bargaining Power, Fear of Disagreement, and Wage Settlements: Theory and Evidence From U.S. Industry," *Econometrica*, 1986, pp. 1055-78.

Table 1
Descriptive Statistics

Variable	Mean	Std. Dev.
Wage (w)	710.608	159.113
Outside Wage (x)	446.212	82.896
Number of Teachers (L)	155.230	196.153
City School District[a]	0.078	0.269
Relative Proportion of Vote Republican in County[a]	8.11e-4	0.058
Percentage of Workers Covered by Collective Agreement in Region[a]	26.691	6.121
County Unemployment Rate[a]	6.903	2.546
Current Enrollment	2357.50	3204.80
Proportional Change in Enrollment in District	0.136	6.956
Full Value of Property per Pupil	168.209	229.741
Percentage of Students on Welfare	14.226	10.876
Number of Schools in District	4.206	4.953
Percentage of Non-white Students in District	5.516	12.829
School District in an SMSA	0.388	0.487
Percentage Average Daily Attendance	67.270	2.519
Observation from 1983	0.310	0.463
Observation from 1986	0.353	0.478
Observation from 1989	0.337	0.473

a: In the estimations, this variable is measured in terms of deviations from overall means. The value presented here is the mean of the pooled data from which the deviations were calculated.
Notes: All monetary variables are in 1982 dollars. There were 1491 observations.

Table 2
Linear Employment Determination Model Results
(Standard Errors in Parentheses)

Variable	OLS1[a]	OLS2[b]	OLS3[c]	IV[d]
Intercept	-4.056	-4.321	-3.414	-3.275
	(1.073)	(0.762)	(0.807)	(0.310)
Inside Wage (*w*)	0.668	0.668	0.924	0.277
	(0.090)	(0.082)	(0.108)	(0.038)
Outside Wage (*x*)	-0.198	-0.173	-0.514	0.042
	(0.181)	(0.072)	(0.126)	(0.046)
City[e]	0.103	0.102	0.086	0.049
	(0.039)	(0.039)	(0.039)	(0.017)
Prop.	0.304	0.275	0.173	0.171
Republican[e]	(0.183)	(0.183)	(0.186)	(0.081)
Union Coverage[e]	8.91e-4	4.25e-4	1.03e-3	7.87e-4
	(2.08e-3)	(2.08e-3)	(2.07e-3)	(8.66e-4)
Unemployment	-0.024	-0.028	-0.028	-4.24e-3
Rate[e]	(0.006)	(0.006)	(0.006)	(2.54e-3)
Log(Enrollment)	0.811	0.811	0.798	0.859
	(0.015)	(0.015)	(0.015)	(0.006)
Change in	-1.80e-3	-1.53e-3	-1.36e-3	7.17e-4
Enrollment	(1.23e-3)	(1.22e-3)	(1.22e-3)	(5.16e-4)
Log(Full Value of	0.011	0.012	0.015	0.015
Property)	(0.011)	(0.011)	(0.011)	(0.004)
Pct. Welfare	-1.35e-4	-6.00e-5	-4.06e-4	-6.70e-4
	(1.04e-3)	(1.03e-3)	(1.03e-3)	(4.40e-4)
Number of	0.013	0.013	0.013	6.41e-3
Schools	(0.003)	(0.003)	(0.003)	(1.15e-3)
Pct. Non-white	-2.41e-3	-2.18e-3	-1.38e-3	1.01e-3
	(9.16e-4)	(9.14e-4)	(9.35e-4)	(4.00e-4)
Average Daily	-5.85e-3	-4.87e-3	-6.85e-3	-5.25e-3
Attendance	(5.81e-3)	(5.82e-3)	(5.79e-3)	(2.38e-3)
SMSA	-0.069	-0.106	-0.069	-0.036
	(0.050)	(0.029)	(0.031)	(0.014)
1986	0.077	0.068	0.095	
	(0.038)	(0.038)	(0.038)	
1989	0.076	0.027	0.078	
	(0.057)	(0.049)	(0.049)	
Number of Observations	1748	1748	1746	1062
R^2	0.874	0.875	0.875	0.984

a: The outside wage used in this regression was estimated using school district-specific work force characteristics and the coefficients from a preliminary selection-corrected human capital regression (see section V for details).

b: The outside wage used in this regression is the county-wide average wage.

c: The outside wage used in this regression is the measure used in Currie (1991), namely the average wage across all other school districts in the same county. There were two counties containing only one school district.

d: The wage is instrumented using the lagged wage and a year indicator. Information on the lagged wage was missing the first observation for each school district, and thus these observations were eliminated from the sample. The outside wage used in this regression was estimated using school district-specific work force characteristics and the coefficients from a preliminary selection-corrected human capital regression (see section V for details).

e: To facilitate interpretation of the results, this variable is included in the regression as the deviation from its statewide mean.

Table 3
Results from Estimating the Simultaneous Equations Structural Models
(Equations (8) and (9), Standard Errors in Parentheses)

Variable	Model 1 $(q = 0)$		Model 2[a] $(p = q)$		Model 3 $(p \neq q)$	
	t=1	*t* free	*t*=1	*t* free	*t*=1	*t* free
City[b] (p)	-0.249 (0.070)	-0.260 (0.100)	0.216 (.067)	-.022 (.020)	.025 (.063)	-.001 (.040)
Prop. Republican[b] (p)	-2.64 (0.435)	-2.27 (0.843)	-0.755 (.319)	-.202 (.160)	-.871 (.321)	-.603 (.333)
Union Coverage[b] (p)	-0.002 (0.004)	-0.001 (0.005)	0.008 (.004)	-4.34e-4 (5.33e-4)	.008 (.004)	.005 (.003)
Unemployment Rate[b] (p)	0.067 (0.012)	0.072 (0.023)	-0.061 (.008)	.005 (.004)	-.054 (.008)	-.038 (.017)
1986 (p)	1.06 (0.109)	1.14 (0.348)	0.517 (.063)	.069 (.050)	.523 (.064)	.338 (.150)
1989 (p)	0.425 (0.094)	0.470 (0.143)	-0.045 (0.069)	0.007 (0.012)	-0.031 (0.067)	-0.017 (0.048)
City[b] (q)	-	-	0.216 (0.067)	-0.022 (0.020)	0.551 (0.225)	0.539 (0.238)
Prop. Republican[b] (q)	-	-	-0.755 (0.319)	-0.202 (0.160)	3.61 (1.89)	5.20 (2.34)
Union Coverage[b] (q)	-	-	0.008 (0.004)	-4.34e-4 (5.33e-4)	0.026 (0.013)	0.026 (0.014)
Unemployment Rate[b] (q)	-	-	-0.061 (0.008)	0.005 (0.004)	-0.200 (0.029)	-0.223 (0.039)
1986 (q)	-	-	0.517 (0.063)	0.069 (0.050)	1.57 (0.429)	1.43 (0.408)
1989 (q)	-	-	-0.045 (0.069)	0.007 (0.012)	1.73 (0.521)	1.66 (0.485)
Union preferences (t)	1	0.932 (0.508)	1	6.29 (1.88)	1	2.11 (1.12)
Returns to Scale (α)	0.516 (0.006)	0.514 (0.033)	0.480 (0.005)	0.742 (0.054)	0.480 (0.005)	0.559 (0.072)

Variable	Model 1 $(q=0)$		Model 2[a] $(p=q)$		Model 3 $(p \neq q)$	
	t=1	*t* free	*t*=1	*t* free	*t*=1	*t* free
Intercept $\left(\gamma/\lambda\right)$	-0.693 (0.568)	-0.699 (0.572)	-1.09 (0.616)	-0.393 (0.341)	-1.06 (0.610)	-0.852 (0.556)
Prop. Republican[b] $\left(\gamma/\lambda\right)$	0.252 (0.117)	-0.248 (0.119)	0.109 (0.112)	-0.157 (0.073)	-0.443 (0.236)	-0.535 (0.218)
Log(Enrollment) $\left(\gamma/\lambda\right)$	0.436 (0.009)	0.438 (0.031)	0.475 (0.009)	0.233 (0.049)	0.468 (0.009)	0.398 (0.065)
Change in Enrollment $\left(\gamma/\lambda\right)$	-1.49e-3 (8.17e-4)	-1.50e-3 (8.27e-4)	-1.45e-3 (8.87e-4)	-7.73e-4 (4.66e-4)	-1.66e-3 (8.84e-4)	-1.44e-3 (7.81e-4)
Log(Full Value of Property) $\left(\gamma/\lambda\right)$	0.024 (0.006)	0.024 (0.006)	0.028 (0.006)	0.013 (0.004)	0.025 (0.006)	0.021 (0.006)
Pct. Welfare $\left(\gamma/\lambda\right)$	-3.28e-4 (5.47e-4)	-3.25e-4 (5.52e-4)	-4.76e-4 (5.87e-4)	-1.74e-4 (3.01e-4)	-3.96e-4 (6.04e-4)	-3.34e-4 (5.18e-4)
Pct. Non-white $\left(\gamma/\lambda\right)$	-1.80e-4 (4.63e-4)	-1.82e-4 (4.66e-4)	1.91e-4 (5.00e-4)	-1.33e-4 (2.49e-4)	-3.03e-4 (5.06e-4)	-2.64e-4 (4.33e-4)
log(Outside wage) $\left(\gamma/\lambda\right)$	1.10 (0.098)	1.10 (0.098)	1.09 (0.106)	1.06 (0.053)	1.10 (0.106)	1.09 (0.091)
SMSA $\left(\gamma/\lambda\right)$	-0.020 (0.029)	-0.020 (0.029)	-5.58e-4 (3.13e-2)	-0.011 (0.016)	-0.024 (0.032)	-0.021 (0.028)
1986 $\left(\gamma/\lambda\right)$	0.208 (0.015)	0.211 (0.015)	0.095 (0.014)	0.115 (0.012)	-0.066 (0.042)	-0.023 (0.049)
1989 $\left(\gamma/\lambda\right)$	0.128 (0.025)	0.131 (0.026)	0.108 (0.106)	0.047 (0.019)	-0.158 (0.045)	-0.124 (0.046)
Iterations to Convergence	4	44	3	47	7	38
σ^2_{wage}	0.015	0.015	0.013	0.014	0.013	0.013
$\sigma^2_{employment}$	0.156	0.156	0.159	0.156	0.155	0.155
$\sigma_{wage,employment}$	0.007	0.007	0.006	0.007	0.007	0.007
System of Equations Mean Squared Error	0.169	0.169	0.170	0.169	0.166	0.166
Adjusted R^2 (Wage Equation)	0.682	0.682	0.722	0.689	0.720	0.720
Adjusted R^2 (Employment Equation)	0.831	0.832	0.829	0.832	0.832	0.834

a: The estimated coefficients for both bargaining power approximating equations are constrained to be identical and are shown as coefficients of both the *p* and *q* approximating equations.

b: To facilitate interpretation of the results, this variable is included in the regression as the deviation from its statewide mean.

Notes: There were 1491 observation used in estimating each of the specifications. The outside wage used in all models was estimated using school district-specific work force characteristics and the coefficients from a preliminary selection-corrected human capital regression (see section V for details). In the models with *t* free, a grid search was performed over the range [0,3] to find the optimal starting value for *t*.

Table 4
Means and Standard Deviations
of Fitted p and q Values

Model Specification	p	p	q	q
	t=1	t estimated	t=1	t estimated
Labor Demand $(q = 0)$	0.622 (0.097)	0.631 (0.102)	-	-
Strongly Efficient $(p = q)$	0.539 (0.081)	0.507 (0.008)	0.539 (0.081)	0.507 (0.008)
Unrestricted $(p \neq q)$	0.541 (0.077)	0.527 (0.052)	0.716 (0.207)	0.705 (0.210)

Table 5
District by District T-tests on Estimated p and q

	t-value	Pct. of School Districts (t=1)	Pct. of School Districts (t estimated)
Panel A H$_0$: $q = 0$	$\|t\| < 1.645$	0%	0%
	$1.645 \leq \|t\| < 1.96$	0%	0%
	$1.96 \leq \|t\|$	100%	100%
Panel B H$_0$: $p = q$	$\|t\| < 1.645$	13.0%	17.3%
	$1.645 \leq \|t\| < 1.96$	0.7%	0.2%
	$1.96 \leq \|t\|$	86.4%	82.6%

Table 6
Estimates of Education Demand Functions

Variable	Model 1 (Uncorrected Expenditure per pupil)	Model 2 (Corrected Expenditure per pupil)	Model 3 (Uncorrected log of Expenditure per pupil)	Model 4 (Corrected log of Expenditure per pupil)
Intercept	2801.295 (659.780)	1043.509 (386.139)	7.612 (0.587)	6.704 (0.556)
Full Value of Property per Pupil	0.677 (0.033)	0.403 (0.019)	-	-
Log of Full Value of Property per Pupil	-	-	0.091 (0.011)	0.068 (0.010)
Proportion of Students on Welfare	-8.627 (1.218)	-1.220 (0.715)	-2.92e-3 (1.09e-3)	-1.87e-4 (1.04e-3)
Proportion of Republican Vote[a]	104.546 (227.655)	201.657 (133.709)	0.172 (0.201)	0.332 (0.190)
Proportion of Minority Students	6.144 (1.130)	0.952 (0.664)	6.31e-4 (1.00e-3)	-1.39e-3 (9.47e-4)
Average Daily Attendance	-13.732 (7.255)	-1.092 (4.261)	-7.65e-3 (6.42e-3)	-1.78e-3 (6.08e-3)
County Unemployment[a]	-31.204 (6.956)	-3.488 (4.086)	-0.031 (0.006)	-0.020 (0.006)
Proportional Change in Enrollment	-7.963 (1.534)	-2.019 (0.901)	-3.48e-3 (1.32e-3)	-1.84e-3 (1.25e-3)
If in SMSA	401.457 (32.235)	328.387 (18.932)	0.159 (0.028)	0.243 (0.027)
1986	256.850 (45.915)	44.100 (26.967)	0.178 (0.041)	0.074 (0.038)
1989	640.460 (51.231)	400.857 (30.090)	0.339 (0.045)	0.335 (0.043)
R^2	0.556	0.564	0.281	0.273

a: To facilitate interpretation of the results, this variable is included in the regression as the deviation from its statewide mean.
Notes: All monetary variables are in 1982 dollars. The mean of the uncorrected expenditure per pupil is 2005.88 and the mean of the corrected expenditure per pupil is 1275.83. Standard errors are in parentheses.

Appendix A
The Equivalence Between Differential Bargaining Power
over Wages and Employment and
Differential Preferences for Wages and Employment

Another potential interpretation of the structural model suggested by the Manning approach is one in which, instead of allowing for different bargaining powers over wages and employment, we assume the same bargaining power over both wages and employment and allow the extra degree of freedom to determine the relative weight that the union puts on the employment relative to wage gains. For example, consider the situation where the school board, as before, has an objective function of the form

$$\gamma L^{\alpha} - \lambda w L$$

while the union's objective function is now

$$L^{\beta}\left(w^{\tau} - x^{\tau}\right)^{1-\beta} \tag{3}$$

and the union's bargaining power over both wages and employment is *f*. Since the bargaining power over employment and wages is now identical, we can now solve a modified version of equation (3) for both employment and wages. That is, we want to solve

$$\max_{w,L}\left(L^{\beta}\left(w^{\tau} - x^{\tau}\right)^{1-\beta}\right)^{\phi}\left(\gamma L^{\alpha} - \lambda w L\right)^{1-\phi} \tag{A.1}$$

This gives, as a solution to the first-order conditions,

$$w = x\left(\frac{\phi\beta + (1-\phi)\alpha}{\phi\left[\beta - (1-\beta)t(1-\alpha)\right] + (1-\phi)\alpha}\right)^{1/\tau} \tag{A.2}$$

$$L = \left(\frac{\gamma}{\lambda x}\left(\frac{\phi\beta + (1-\phi)\alpha}{\phi\beta + (1-\phi)}\right)\left(\frac{\phi\beta + (1-\phi)\alpha}{\phi\left[\beta - (1-\beta)t(1-\alpha)\right] + (1-\phi)\alpha}\right)^{-1/\tau}\right)^{\frac{1}{1-\alpha}} \tag{A.3}$$

After some manipulation, we see that we can rewrite the parameters *p* and *q* of the initial model as follows.

$$p = \frac{\alpha\phi(1-\beta)}{\alpha + \phi\left(\beta(1-\alpha) - (1-\beta)\right)} \tag{A.4}$$

$$q = \frac{\phi\beta}{\phi\beta + (1-\alpha)} \tag{A.5}$$

Thus there is clearly a degree of equivalence between the model with differential bargaining powers and equal weights for the utility of wage gains and employment in the union utility function (as presented in section III) and the model with equal bargaining powers and differential weights on the utility of wage gains and employment in the union utility function.

Appendix B
Results from Human Capital Regression*

Variable	Mean	Without Selection Bias Correction	With Selection Bias Correction
Intercept	1	2.652	2.288
	(0)	(0.040)	(0.186)
Female	0.481	-0.451	-0.490
	(0.500)	(0.008)	(0.021)
Age	37.813	0.118	0.121
	(13.380)	(0.002)	(0.002)
Age^2	1608.891	-1.26e-3	-1.28e-3
	(1107.131)	(1.99e-5)	(2.16e-5)
If in SMSA	0.886	0.241	0.264
	(0.318)	(0.012)	(0.017)
1986	0.399	-0.027	-0.047
	(0.490)	(0.009)	(0.013)
1989	0.283	0.198	0.221
	(0.450)	(0.011)	(0.016)
Primary School Only	0.027	0.144	0.135
	(0.162)	(0.031)	(0.031)
Between Primary and High School	0.206	0.260	0.258
	(0.404)	(0.023)	(0.023)
High School	0.300	0.516	0.523
	(0.458)	(0.022)	(0.023)
Between High School and BA / BS	0.224	0.645	0.650
	(0.417)	(0.023)	(0.023)
BA / BS	0.104	0.887	0.903
	(0.306)	(0.024)	(0.026)
Between BA / BS and Masters	0.047	0.974	0.972
	(0.211)	(0.027)	(0.027)
Masters and Beyond	0.059	1.037	1.054
	(0.236)	(0.026)	(0.028)
Inverse Mills Ratio	1.292	-	0.202
	(0.189)		(0.101)
Number of Observations	26958	26958	26958
R^2		0.387	0.387

Notes: The dependent variable is the log of real usual weekly earnings. It has a mean of 5.668 and a standard error of 0.794. Standard errors are in parentheses, except for the "Mean" column, in which case standard deviations are in parentheses.

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