# WHAT DO (PUBLIC SECTOR) UNIONS DO?

# WAGE AND EMPLOYMENT DETERMINATION AMONG ONTARIO PUBLIC SCHOOL TEACHERS

Janet Currie Neelin

University of California at Los Angeles

UCLA Working Paper No. 542
January 1989

This paper is based on a chapter of my doctoral dissertation. I would like to thank David Card, John Dinardo, Bruce Fallick, Richard Quandt, Duncan Thomas, and seminar participants at UCLA and UCSB for helpful comments. Craig Crawford of the Education Relations Commission and Thomas Taylor of the Ontario Ministry of Education provided much of the data. Financial support from the Social Science and Humanities Research Council of Canada, the Industrial Relations Section at Princeton University, and the Alfred P. Sloan Foundation is gratefully acknowledged. The views expressed, and any errors, are my own.

## Abstract

The efficient contracts model is contrasted with a very simple model of supply and demand in the market for public school teachers. The paper departs from the long tradition of identifying labor demand curves by assuming that labor supply is perfectly elastic at the union wage. It is also one of the first papers to test an efficient contracts model using public sector data. The main question addressed is whether or not a simple supply and demand model can explain wage and employment determination in this market as well as a more complicated contracting story.

The estimated contract curve is vertical, but a more interesting result is that the supply/demand model fits these data just as well. The signs of the estimated elasticities are consistent with theory and the overidentifying restrictions are not rejected. Estimated point elasticities of demand are less than one in absolute value, while the estimated inverse elasticity of supply is consistently positive but very small.

Estimates of both models suggest that the employment of teachers in Ontario is efficient from a societal point of view.

## Introduction:

The percentage of American public employees who are unionized has increased dramatically from essentially zero in 1965 to about forty percent today. Since the public sector accounts for fifteen percent of nonagricultural payroll employment in the United States and twenty five percent in Canada, it is more important than ever before to understand what public sector unions do, and in particular, whether their existence is likely to lead to more or less efficient economic outcomes.

Dunlop (1944) argued that an effective union would raise the wage above the competitive level and that employers would react by reducing employment along the labor demand curve. Dunlop's union has been called a "monopoly union" since its introduction into a competitive labor market would involve the sort of deadweight loss typically associated with monopoly.

An alternative "efficient contracts" model of unionized labor markets has been proposed in which wage and employment outcomes lie on the locus of tangencies between employers' iso-profit (or iso-cost) curves and unions' indifference curves.[1] Every point on the curve is efficient in the sense that neither party can gain except at the expense of the other. If the contract curve is vertical, then the existence of the union does not involve a deadweight loss as the union merely extracts rent from the employer.

Several recent papers use private sector data to compare the explanatory power of these two models.[2] All assume that labor supply is perfectly elastic at the union wage. They find that the monopoly union can be rejected[3] but they do not provide strong support for the efficient contracts model either.

In this paper, the efficient contracts model is contrasted with a very simple model of supply and demand in the market for public school teachers in which employment is also efficiently determined. The paper departs from the long tradition of identifying labor demand curves by assuming that labor supply is perfectly elastic at the union wage. It is also one of the first papers to test an efficient contracts model using public sector data.[4] The question addressed is whether or not a simple supply and demand model can explain wage and employment determination in this market as well as a more complicated contracting story.

Given the functional forms adopted below, the reduced form of the employment equation from the supply and demand system is identical to the contract curve except that the latter includes the wage as an explanatory variable. If the contract curve is "strongly efficient", or vertical, even this distinction disappears. Thus there appears to be little basis for choice between these two models on theoretical grounds.

The study uses contract data for public school teachers in the Canadian province of Ontario between 1975 and 1983. Neither the vertical contract curve model, nor the alternative supply/demand model can be rejected.

When efficient contracting is the maintained hypothesis, the test for strong efficiency involves checking whether or not the wage can be excluded from the employment equation. It is in principal difficult to find suitable instruments for the wage because any variable that affects the utility of the union or the cost curves of the employer will enter the contract curve.[5] Here, as in past studies, the contract curve model is identified by assuming that lagged values of the exogenous variables can be used as instruments for the wage.

The supply/demand model can be identified using more substantive over-identifying restrictions. Supply is identified by assuming that demand depends on an exogenously determined number of pupils, other educational expenditures, and the local tax base, while demand is identified by assuming that labor supply depends on various measures of the alternative wage.

The supply and demand approach produces estimates of supply and demand elasticities which are of interest in their own right. For example, it has been argued that because the demand for public services is inelastic, public sector unions should not be given the right to strike. The results presented below suggest that the demand for teachers in Ontario is indeed inelastic.

Another issue which can be addressed using the supply/demand framework is whether or not there is monopsony in the market for teachers as several recent studies suggest.[6] The results indicate that the supply curve is only slightly upward sloping,

so employers enjoy very little potential monopsony power.

The paper is organized as follows. Section 2 presents the models to be estimated. Section 3 provides a description of these data. Section 4 gives the main results. The arguments are summarized in Section 5.

## Section 2: Models of Wage and Employment Determination

### 2a: Supply and Demand in the Market for Teachers

Consider a monopsonistic market with a smooth upward sloping labor supply curve. In such a market, a positive relationship between wages and employment could reflect shifts in the labor demand curve along a stable supply curve. Although monopsonists equate the marginal revenue product of labor with its marginal cost, it is not possible to distinguish empirically between marginal cost curves and labor supply curves. In what follows I will simply refer to the supply curve for labor.

Assume that labor supply varies positively with the own wage and negatively with the alternative wage:

(1) $\ln(E) = j_0 + j_1\ln(W) + j_2\ln(WA)$

where **E** is employment, **W** is the own wage and **WA** is the alternative wage. An increase in the alternative wage shifts the labor supply curve inward, so that at a constant own wage, employment will be reduced. If wage-employment outcomes lie along the supply curve, then the wage and the alternative wage will enter a reduced form employment equation with positive and negative signs, respectively.

Labor demand is assumed to vary negatively with the own

wage, and positively with the number of pupils,:

(2) $\ln(E) = k_0 + k_1\ln(W) + k_2\ln(P) + k_3\ln(K) + k_4\ln(Q)$

where P is the number of pupils, K represents other factors which are involved in the production of education, and Q is a vector of other variables which affect the demand for education, such as the local tax base and economic conditions.

From (1) and (2), the reduced form equation for employment is:

(3) $\ln(E) = [j_1/(j_1-k_1)]*\{[k_0-(k_1*j_0)/j_1] - (k_1*j_2/j_1)*\ln(WA) + k_2\ln(P) + k_3\ln(K) + k_4\ln(Q)\}$

The corresponding reduced form for wages is:

(4) $\ln(W)= [1/(j_1-k_1)]*\{(k_0-j_0) - j_2\ln(WA) + k_2\ln(P) + k_3\ln(K) + k_4\ln(Q)$

The supply/demand model predicts that the alternative wage will enter negatively in the reduced form for employment, and positively in the reduced form for wages. If more than one measure of the alternative wage is available, the demand elasticity, $k_1$, will be overidentified. K and the elements of Q provide overidentifying restrictions on the supply elasticity, $j_1$.

In the empirical work below, wages in surrounding school districts, and the average income in the district are used as measures of the alternative wage. K is proxied using total non-instructional expenditures, while Q includes average and total federal and provincial tax liabilities in each area. Local employment indices and manufacturing wages are included in both

equations, as they may affect the alternative wage, but they also reflect economic conditions in each area.

2b: Efficient Contracting and the Market for Teachers

Assume that school boards facing a monopoly union would minimize costs subject to an output constraint:

(5) $\text{Min}_{(\text{wrt } E,K)}\ C=W*E + R*K - L(f(E,K) - P*Q)$

where R is a vector of non-wage factor prices, f() is the production function, P is the exogenously determined number of students, L is the shadow price of educational services, and Q is an unobservable index of the quality of education that varies between zero and one. If the production function is Cobb-Douglas, then taking logarithms and solving for labor demand yields an expression for ln(E) which is a linear function of ln(P), ln(Q), ln(R), and ln(W). Employment varies positively with P and negatively with W as in equation (2).

A contract curve similar to equation (3) can be developed by noting that the contract curve traces out the locus of tangencies between the board's iso-cost curves and the union's indifference curves.[7] Along an iso-cost curve, the elasticity of the wage with respect to employment, assuming constant K, is $-[(W-(L*f_E)/W)]$. In the Cobb-Douglas case this expression reduces to $-[(W-(L*P*Q/E))/W]$. The Stone-Geary utility function, $U(W,E)=k(W-WA)^{b}E^{(1-b)}$, implies that along an indifference curve the corresponding elasticity is $(-(1-b)/b)[(W-WA)/W]$. Equating these expressions and taking a logarithmic approximation yields:

(6) $\ln E = a + \ln P + (c-1) \ln W - c \ln WA + \ln Q$

where c=(1-b)/b. The model implies that employment is unit elastic with respect to the number of pupils and that the coefficients on the own and alternative wage sum to one.

Alternatively, if the union maximizes the expected utility of a typical union member, g(*), then the union utility function is: U(W,E)=(E/E')*g(W) + [1-(E/E')]*g(WA) where E' is the fixed union membership. Setting the slope of the iso-cost curve equal to the slope of the union indifference curve yields:

(7) [g(WA)-g(W)]/[w*g'(W)] = -[(W-(L*P*Q)/E)]/W

where L is the Lagrange multiplier. Taking a second order Taylor series expansion of g(WA) around g(W) and solving for ln(E) yields:

(8) $\ln(E) = b_0 + \ln(P) - \ln(WA) - (r/2)*(\ln*(W) - \ln(WA))^2 + \ln(Q)$

This model implies coefficients of one and negative one on pupils and the alternative wage, respectively. The own wage has only a second order effect.

Following Brown and Ashenfelter (1986), and assuming that the unobserved quality index can be proxied using the tax variables, the two contract curve models, (6) and (8), and the monopoly union model, (2), can be nested. Omitting second order terms, the contract curve equation to be estimated is:

(9) $\ln(E) = m_0 + m_1\ln(W) + m_2\ln(WA) + m_3\ln(P) + m_4\ln(K) + m_5\ln(Q)$

Brown and Ashenfelter argue that if the alternative wage enters equation (9) then the monopoly union model can be rejected. Card

(1986) shows that if adjusting employment is costly and the alternative wage can be used to predict future union wages, then employment may be a function of the alternative wage, even when wage-employment outcomes lie on the labor demand curve. However, preliminary vector-autoregressions (Neelin, 1988) indicated that the alternative wage was not a good predictor of the own wage in these data when lagged wages were controlled for. A static model is estimated below.

**Section 3: The Data**

This study uses contract data to examine wage and employment patterns for public school teachers in the Canadian province of Ontario between 1975, when teachers received the right to bargain collectively, and 1983 when provincial inflation restraint legislation temporarily suspended that right.[8] These data have several features which make them useful for the purposes of this study. First, each school board bargains independently with its union local, and wage and employment data are available on an annual basis for all two hundred school board-union bargaining pairs in the province.[9]

Measures of additional covariates which are used below to identify supply and demand are also available. These measures include: 1) the number of pupils and non-instructional expenditures for each bargaining unit, and 2) average manufacturing wages, employment indices, average income, average federal and provincial taxes and total federal and provincial taxes for cities in each county.

Finally, because elementary, secondary and Catholic school teachers are represented by three different unions in Ontario, there are multiple observations per year in each county. The same public school board bargains with the elementary and secondary teachers' unions in each school district. Hence, data for these bargaining pairs can be differenced in order to control for unobservable variables which are shared by the two unions in a given year and county, as well as for unobservable fixed effects associated with the individual bargaining pairs. Unfortunately, Catholic boards do not exist in some areas, and where they do, they typically cover larger geographical areas than elementary boards. Catholic boards also receive funding from private sources and thus may be affected differently by local variables. Catholic boards are excluded from the sample when models including geographical fixed effects are discussed below. Data sources, complete definitions, and variable means for each year and union type are shown in Appendix 1.

Several reasons can be given for focusing on the market for teachers. First, a quarter of U.S. state and local budgets went to direct expenditures on elementary and secondary education in 1986. Teacher salaries are the largest single component of these expenditures. Second, a significant literature exists which claims that monopsony is important in this market. Finally, the efficient contracts literature proceeds on the assumption that union preferences can be represented by a utility function. This assumption is most palatable when the union is a democratic

organization representing homogeneous members. Teacher unions come close to fulfilling these requirements.

The teacher unions are also typical of other public sector groups in the sense that no obvious control group exists. Because the right to collectively bargain did not exist before 1975, it is difficult to obtain wage and employment information prior to that date. And since all public school teachers must belong to a union, it is not possible to estimate union/non-union wage differentials as one would do with private sector employees.

A preliminary data analysis suggested that both the supply/demand, and the efficient contracts model might provide a reasonable description of these data. Employment varies positively with the real wage in the raw data, a finding which is consistent with demand shifting inwards along an upward sloping labor supply curve.

The period under study was one of declining enrollments, yet employment generally fell more slowly. Bargaining over employment and/or pupil-teacher ratios took place in many districts. Teachers negotiated a variety of clauses regulating pupil/teacher ratios, maximum class sizes, and the minimum number of teachers per school. Arbitrator's reports provide a more detailed look at the employment provisions in some contracts. Staff or workload provisions were in dispute in 45 percent of the fifty-seven contracts that were arbitrated over the sample period. Given that the pupil-teacher ratio can be interpreted either as an employment issue or as a working condition, it is

interesting to note that arbitrators often distinguish between the pupil-teacher ratio and "workload". The latter depends on the number of courses taught, and the number of hours of preparation time allowed during the school day. Some arbitrators also state explicitly that the purpose of pupil-teacher provisions is to prevent boards from lowering employment "beyond the level dictated by declining enrollments".

The most serious limitations of these data are the following: First, only the maximum teacher salary in each district is available.[10] To qualify for this wage, a teacher must have a masters degree in education and ten years of experience. Most teachers now do have the masters degree. The use of the maximum salary does control for unobserved differences in teacher quality and seniority that would affect the average wage. Fringes and benefits, and hours of work are not available.

The measure of the alternative wage used here is the employment weighted average of wages in adjoining school districts. Implicit in the use of this measure, are the assumptions that teachers looking for new jobs prefer to remain in the profession and that they wish to avoid relocation. Data about the vocational and locational choices of those who leave teaching jobs in Ontario are not available. This alternative wage measure cannot always be strictly less than the own wage in each board. But given that teachers cannot be certain that they will obtain a job in an adjacent board, the expected wage at the alternative job may well be less than that on the current job.

Measures of local property taxes faced by voters in each school board are not available. The federal and provincial tax variables used below are likely to be quite imperfect proxies for school boards' ability to pay. On the other hand, from a local perspective they are exogenous variables. Another problem is that the tax and income data come from tax returns, and I am unable to distinguish between persons filing singly and those filing jointly.

The non-instructional expenditures variable does not reflect underlying community characteristics as well as it might, because it includes equalization payments by the provincial government to poorer school districts.[11] These data do have the advantage of being the actual amount spent per student rather than an imputed ability to pay measure.[12]

Finally, it is difficult to determine what effect the existence of the federal anti-inflation board had on contract settlements over the 1975-1978 period. I am aware of only 22 contracts which were rolled back by the AIB, but the existence of the board may have depressed wages because of the threat of a roll-back. In addition, 74 contracts were affected by strikes, arbitrations and/or legislated settlements. These contracts are a small fraction of the sample and including dummy variables for the AIB, or for contract disputes does not change the results reported below.

## 4: Estimation Results

### 4a: Full Sample Results

Estimates of the alternative models are shown in Table 1. First logarithms were taken and then all variables were measured in deviations from board means in order to remove any unobserved variables that remain fixed over time in each board (fixed effects). Estimates have been corrected for arbitrary heteroskedasticity and autocorrelation as noted in the tables. Columns (1) and (2) show estimates of the contract curve by Ordinary Least Squares (OLS) and Three Stage Least Squares (3SLS) respectively. Lags of the exogenous variables are used as instruments for the wage. Together, they explain 45 percent of the variation in the current wage. The estimates show that the hypothesis of strong efficiency cannot be rejected since the coefficient on the wage is statistically insignificant in both specifications, and the overidentifying restrictions are not rejected in the 3SLS regression. Note that identification depends on the assumption of a static model.

The alternative wage as measured by wages in surrounding school districts is negative and significant in column (1). Hence, the monopoly union model can be rejected. The coefficient on the alternative wage is close to one in absolute value as the rent maximization model predicts. The coefficient is similar, although not significant at the ninety-five percent level, in column (2).

Average income and local wages in manufacturing are

positive and statistically significant in the OLS but insignificantly different than zero in the 3SLS specifications. In both specifications employment rises with total tax paid, and falls with average tax paid, suggesting that for given average income levels, boards with large budgets employ more teachers, while those with high average tax bills hire fewer teachers, ceteris parabis. Boards with more students hire more teachers, but the elasticity is less than one indicating that larger boards have higher pupil/teacher ratios. Finally, teachers seem to be complements to non-instructional expenditures in the production of education.

Ordinary least squares estimates of reduced form equations for supply and demand are shown in columns (3) and (4). The coefficients in (3) are virtually identical to those in (1) and the pattern of signs on alternative wages and on the number of pupils is consistent with the supply/demand model. The wage equation indicates that wages vary positively with alternative wages, average income, and the local employment index, confirming that wage rates respond to changes in teachers' alternative opportunities. The wage also increases with the number of pupils, suggesting that positive shifts in demand move teachers along an upward sloping supply curve. Average tax paid has a small but statistically significant negative effect on the wage, ceteris paribus, while the total tax paid is not statistically significant. Frey (1975) and Easton (1988) also find that measures of ability to pay have little effect on teacher

salaries, while measures of alternative wages have large positive effects.

Restricted estimates of the reduced forms are given in columns (5) and (6).[13] Restrictions were imposed using a two-step minimum distance estimator. In the first step, consistent estimates of the parameters were obtained using OLS. Different parameters were estimated for each year of the sample. In the second step, a quadratic form in the estimated parameters, weighted by their estimated covariance matrix, was minimized with respect to the parameters of the reduced form. The overidentifying restrictions, and the restriction that the parameters be the same for each year, were imposed on the reduced form. The quadratic form evaluated at the reduced form parameter values is distributed as a Chi-square and can be used to test the validity of the restrictions. See Hsiao (1986, pgs 104-106) for details. The test can be viewed as a specification test as well as a test of the overidentifying restrictions, because a left-out variable that was time-varying and correlated with the included exogenous variables would cause parameter values to differ from year to year.

Only the alternative wage and the number of pupils are statistically significant in the restricted reduced form for employment. The coefficient on number of pupils is very similar to the one in column (3), while the coefficient on the alternative wage is about half its column (3) value. The restricted reduced form for wages has a coefficient on the

alternative wage almost equal to that in column (4) while the coefficient on the number of pupils is about three times the column (4) value. The negative coefficient on average tax paid is quite similar in columns (6) and (4). Several variables including average income, local manufacturing wages, and the local employment index change sign when the restrictions are imposed, but none are statistically significant in the reduced form equations. The Chi-squared test of the overidentifying restrictions is 43.56 with 116 degrees of freedom, indicating that they cannot be rejected at conventional levels of statistical significance.

The elasticity of demand can be computed by dividing the coefficient on the alternative wage from the restricted reduced form for employment, with the corresponding coefficient from the wage equation. The estimated elasticity is -.684 with a standard error of .285[14]. Hence, the point estimate indicates that demand for teachers is inelastic, although the null hypothesis of unit elastic demand cannot be rejected. In a cross state survey of wages and employment in education which included post-secondary institutions, Ashenfelter and Ehrenberg (1975) obtain an elasticity of demand of -1. The estimated inverse elasticity of supply is given by the coefficient on the number of pupils in columns (6) divided by the corresponding coefficient from (5), and is equal to .274 with a standard error of .130. Since the inverse elasticity is significantly different than zero, the null hypothesis that supply is perfectly elastic

at the union wage can be rejected.

4b: Results Using Fixed Effects for Geographic Areas

The estimates presented in this section take advantage of the fact that in each year there are two observations for a given public school board. Table 2 shows equations corresponding to columns (1) to (6) of Table 1, where all data are measured as differences between elementary and secondary school boards in the school district.

Board means of all variables were removed before differencing in order to remove fixed effects associated with individual bargaining units. Using the difference between observations in the same area will remove any additional fixed effects associated with a particular geographic area in a given year. Fixed effects for geographic areas reflect any omitted variables which affect both bargaining pairs in a particular area in the same way. Estimates using differences between elementary and Catholic school boards are presented in appendix 2.[15] Note that variables which have identical values for all boards in an area cannot be included in Table 2 as they are absorbed by the area fixed effects.

The coefficients in the OLS employment equations are similar to those in Table 1, although smaller in absolute value. The coefficients in the OLS wage equation are very close to those shown in column (4) of Table 1.

Restricted reduced forms similar to columns (5) and (6) of Table 1, appear in columns (5) and (6).[16] Once again, the

coefficients are quite similar to the unrestricted reduced forms, and the restrictions are not rejected. The estimated elasticity of demand is -.526 with a standard error of .511. The inverse supply elasticity is .178 with a standard error of .084, which is significantly different than zero, but not significantly different from the Table 1 estimate.

4c: Separate Estimates for Boards with Increasing or Decreasing Enrollments

The result that labor supply is not quite perfectly elastic at the union wage may imply that the union has not been able to raise the wage above the competitive level. In this section, separate models are estimated for boards with increasing and boards with decreasing enrollments. The idea is that teachers have more power to raise wages or employment in areas where the demand for their services is growing, other things being equal.

Ordinary Least Squares estimates of the contract curve and reduced forms for wages and employment are shown in Table 3 for all boards, boards with decreasing enrollments, and boards with increasing enrollments. Chow tests shown in the table notes indicate that the hypothesis that the estimated coefficients are the same for boards with increasing and boards with decreasing enrollments can be rejected with ninety-five percent confidence.

The estimated coefficients on the alternative wage and on the number of pupils are smallest in absolute value in the declining enrollment sample, and largest in the increasing enrollment sample. Thus, wage and employment outcomes are more

responsive to alternative wages and to the number of pupils in school boards in which teachers might be expected to have more bargaining power.

The ratio of the coefficient on the alternative wage from the reduced form equation for employment divided by the corresponding coefficient from the reduced form for the wage, yields a rough estimate of the elasticity of demand of -.94 (.064) for the boards with falling enrollments, and -1.10 (.179) for the boards with rising enrollments, where standard errors are shown in parentheses. The inverse elasticity of supply can be computed by using the ratio of the reduced form coefficients on the number of pupils and is equal to .092 (.018) for the boards with declining enrollments and .043 (.021) for boards with increasing enrollments.[17] Hence, the already small degree of monopsony power is reduced where enrollments are increasing, and the labor supply curve is even closer to being perfectly elastic at the union wage.

## 5: Discussion and Conclusions

At this point, it is informative to contrast the results presented above with those that have been obtained using private sector data. Brown and Ashenfelter (1986), Card (1986), Christofides and Oswald (1988), and Wadhwani and Nickell (1988), estimate contract curve equations and find that the coefficients on the own wage and alternative wage are negative and positive respectively. These results are not consistent with either the efficient contracting or the supply/demand framework discussed

above and suggest that the public sector labor market examined here may be fundamentally different than the private sector ones studied by these authors. More recently Card (1988) finds using Canadian manufacturing data that when unanticipated wage changes over the life of a contract are used as instruments for the wage, the null hypothesis that wage and employment outcomes lie on the labor demand curve cannot be rejected.

Eberts and Stone (1986) is the only previous study which examines public sector data for evidence of efficient contracting. They argue that given any wage arrived at through efficient contracting, employers will wish to reduce employment to a level consistent with their labor demand curves. Hence, provisions safeguarding employment must be written into the efficient contract. Using data on 8000 individual teachers, they find a positive correlation between wages and the existence of such employment provisions and they interpret this as evidence of efficient contracting.

My results are much stronger than those cited above. I am unable to reject the hypothesis of a vertical contract curve. However, identification depends on the assumption that a static model is sufficient. The estimates are not consistent with rent maximization as a union objective. If the union's objective function were Stone-Geary, the estimates would imply that teacher unions place greater weight on increasing rents to employed workers than on increasing employment.

The most interesting result of this study is that a simple

static model of supply and demand for teachers fits these data as well as the contracting model. The signs of the estimated elasticities are consistent with theory and the overidentifying restrictions are not rejected. Estimated point elasticities of demand are less than one in absolute value, which suggests that unions do have power to raise the wage without suffering large employment losses. However, the standard errors are large enough that the null hypothesis of unit elastic demand cannot be rejected using these data. The estimated inverse elasticity of supply is consistently positive but very small. It varies in a plausible way according to whether enrollments are increasing or decreasing: The degree of potential monopsony power is even smaller in districts where demand for teacher services is increasing.

Estimates of both models suggest that the employment of teachers in Ontario is efficient from a societal point of view. There does not appear to have been any deadweight loss associated with the unionization of this labor market.

1. See McDonald and Solow (1981), Azariadis (1975), and Baily (1974). Johnson (1985) examines a model in which unions cannot perfectly monitor employment because employers can manipulate output. Unions respond by bargaining over manning rules rather than employment.

2. Brown and Ashenfelter (1986) and McCurdy and Pencavel (1986) examine wages and employment among members of the International Typographical Union in the U.S., while Card (1986) examines American airline mechanics. Doiron (1987) and Martinello (1985) examine the Canadian wood products industry, while Bean and Turnbull (1986) and Bean et al. 1987 study the U.K. coal industry and the U.K. docks respectively. Svejnar (1986), Abowd (1987) and Christofides and Oswald (1988) all look at wage and employment outcomes in a range of industries.

3. For example, Brown and Ashenfelter show that a significant negative coefficient on the alternative wage in an employment equation can be interpreted as a rejection of the monopoly union model. McCurdy and Pencavel (1986) object that for some union utility functions the alternative wage will not enter an equation for employment, so that the Brown and Ashenfelter test could lead to false acceptances of the monopoly union model. However, if the alternative wage does enter the employment equation, then one can reject the monopoly union model.

4. The only other paper I am aware of is Eberts and Stone (1986).

5. Card (1988) solves this problem by using unanticipated changes in the real wage over the life of a contract as an instrument for the nominal contract wage. This approach is not feasible here because the majority of the contracts last only one year.

6. The literature concerned with measuring monopsony in public sector labor markets argues that a positive correlation between the number of employers in an area and the wages of their employees is evidence of monopsony power. Sullivan (1986) and Luizer and Thornton (1986), survey the evidence for nurses and teachers, respectively. Most studies do not control for other factors which might effect wages. More recently, Sullivan (1986), estimates labor supply curves of nurses in order to test the monopsony hypothesis more directly. He identifies labor supply by assuming that hospital caseloads are exogenous and finds that the supply curve for nurses in Maryland is upward sloping. He concludes that employers do have monopsony power.

7. I do not address the issue of whether the preferences of individual union members can be aggregated into a union utility function. The rent-maximization and Stone-Geary utility functions used here are often used to represent union preferences.

8. The legislation suspended bargaining in the public sector for one year and legislated a fixed ceiling on increases in compensation. As a result of the litigation which followed the passage of this legislation, data for 1983/84 school year are unavailable.

9. Bargaining units on Canadian Forces Bases, in hospitals and those which offer French language instruction only are excluded. There are 948 one year, 323 two year and six three year contracts. Contracts run from September to September. Data for strictly private school are not available, but these are considerably less important in Canada than they are in the United States.

10. Lipsky and Drotning (1973) and Luizer and Thornton (1986) find that their coefficient estimates vary depending on whether they measure wages using the salary scale or the average wage. In Ontario, teachers in the top salary category must have at least six years of post-secondary education and ten years of teaching experience. Most Ontario teachers now do have a Masters degree in education.

11. The funding formula takes into account such factors as the provision of language programs, vocational training, and the higher costs of northern school boards.

12. See Landon and Baird (1971), Lipsky and Drotning (1973) or Woodbury (1985), for examples of such imputed measures.

13. Two-stage least squares estimates of supply and demand corresponding to equations (5) and (6) are shown in Appendix 2, Table 1 for the sake of comparison. Two stage least squares estimates which also corrected for arbitrary heteroskedasticity and autocorrelation using the estimated covariance matrix would be asymptotically equivalent to the restricted reduced forms shown above.

14. The standard error can be computed using the "delta method". To find the standard error of b/c, take the (jacobian of b/c transpose)*(covariance matrix of b,c)*(jacobian of b/c).

15. These estimates differ from those presented in the text in several respects. The 3SLS estimate of the coefficient on the wage is significantly negative in the contract curve equation. The independent variables explain only three percent of the variation in differenced wages and only the coefficient on the alternative wage is statistically significant in the OLS wage equation. It is about half the magnitude of the relevant coefficient in Table 1. The overidentifying restrictions are not rejected, but the point estimate of the inverse elasticity of

supply is negative. The estimated demand elasticity is -.763 but is not statistically significantly different than zero.

16. Two stage least squares estimates of supply and demand corresponding to the reduced forms reported in Tables 2 are shown in Appendix 2, Tables 2 for the sake of comparison.

17. The corresponding point estimates from the OLS reduced forms in Table 1 are -1.45 for demand and .089 for supply.

Table 1: Estimates on the Contract Curve and Reduced Forms of the Supply/Demand System: 1975/76-1982/83.
(All Variables Measured in Deviations From Board Means).

| | Contract Curve | | Reduced Forms Demand/Supply | | | |
|---|---|---|---|---|---|---|
| | OLS[a] | 3SLS[b] | OLS | | Restricted[c] | |
| Dependent Variable: | (1) Emp. | (2) Emp. | (3) Emp. | (4) Wage | (5) Emp. | (6) Wage |
| Independent Variables: (Intercepts not shown) | | | | | | |
| Wage | .017 | 2.03 | - | - | - | - |
| | (.066) | (1.37) | | | | |
| Alternative Wage | -.996* | -2.26* | -.984* | .674* | -.426* | .623* |
| | (.089) | (1.00) | (.075) | (.039) | (.283) | (.214) |
| Average Income | .226* | -.060 | .228* | .116* | -.046 | - |
| | (.074) | (.148) | (.073) | (.038) | (.077) | |
| Local Wage in Manufacturing | .190* | -.087 | .191* | .056 | .032 | -.121 |
| | (.058) | (.090) | (.058) | (.028) | (.251) | (.134) |
| Local Emp. Index | -.081* | -.069 | -.083* | .076* | -.139 | -.031 |
| | (.020) | (.093) | (.019) | (.019) | (.097) | (.079) |
| Local Average Tax Paid | -.207* | -.060 | -.207* | -.045* | - | -.078* |
| | (.040) | (.067) | (.040) | (.021) | | (.027) |
| Local Total Tax Paid | .099* | .088* | .099* | .001 | - | .008 |
| | (.015) | (.022) | (.015) | (.008) | | (.025) |
| Number Pupils | .718* | .650* | .719* | .064* | .722* | .198* |
| | (.021) | (.086) | (.021) | (.010) | (.159) | (.094) |
| Non-Instructional Costs | .028* | .054* | .027* | -.006 | - | -.010 |
| | (.014) | (.024) | (.014) | (.007) | | (.007) |
| Degrees of Freedom | 1497 | 1340 | 1498 | 1498 | 1501 | 1499 |
| Sum Sq. Errors | 2.00 | 3.33 | 2.00 | .551 | | |
| R-square | .611 | | .611 | .694 | | |

Notes:

[a] All OLS estimates are corrected for arbitrary heteroskedasticity using White's (1980) procedure. * indicates significance at the 95% level of confidence.

[b] Computed using the estimated covariance matrix from a 2SLS regression to correct for heteroskedasticity. See Neelin (1988)

for details. Lags of the levels of the exogenous variables are used as instruments for the contract wage. Together they explain 45% of the variation in the current wage. The Chi-square test of the over-identifying restrictions is 4.47 with 7 degrees of freedom. Hence, the overidentifying restrictions are not rejected.

[c] The estimates in the last two columns were obtained using a minimum distance procedure. The standard errors allow for arbitrary heteroskedasticity and autocorrelation. See Hsiao (1986) pgs 104-106. The model was first estimated with different parameters for each year. The parameters were then restricted to be the same across years, in addition to the overidentifying restrictions. The overidentifying restrictions on demand are the equality of the ratios of coefficients on pupils, non-instructional costs, average taxes, and total taxes. The overidentifying restriction of supply is that the ratios of coefficients on average income and alternative wages are equal. The Chi-square statistic is 43.56 with 116 degrees of freedom. Hence the restrictions are not rejected at any reasonable level of confidence. The estimated inverse elasticity of supply from the restricted equations is .274 (.130) and the demand elasticity is -.684 (.285). Computations were done using SAS IML and starting values from the OLS reduced forms.

Table 2: Estimates on the Contract Curve and Reduced Forms of the Supply/Demand System: 1975/76-1982/83. Differences Between Elementary and Secondary Boards. (All Variables Measured in Deviations From Board Means).

| | Contract Curve | | Reduced Forms Demand/Supply | | | |
|---|---|---|---|---|---|---|
| | OLS[a] | 3SLS[b] | OLS | | Restricted[c] | |
| Dependent Variable: | (1) Emp. | (2) Emp. | (3) Emp. | (4) Wage | (5) Emp. | (6) Wage |
| Independent Variables: (Intercepts not shown) | | | | | | |
| Wage | -.182 (.100) | -.582 (.773) | - | - | - | - |
| Alternative Wage | -.431* (.164) | -.271 (.472) | -.547* (.137) | .637* (.045) | -.306 (.330) | .582 (.167) |
| Number Pupils | .570* (.028) | .621* (.036) | .561* (.028) | .047* (.013) | .546* (.079) | .098* (.041) |
| Non-Instructional Costs | .009 (.021) | .006 (.018) | .008 (.021) | -.004 (.007) | -.004 (.060) | - |
| Degrees of Freedom | 577 | 497 | 578 | 578 | 578 | 578 |
| Sum Sq. Errors | 1.10 | .904 | 1.11 | .210 | | |
| R-square | .473 | | .467 | .427 | | |

Notes:

[a] All OLS estimates are corrected for arbitrary heteroskedasticity using White's (1980) procedure. * indicates significance at the 95% level of confidence.

[b] Computed using the estimated covariance matrix from a 2SLS regression. See Neelin (1988) for details. Lags of the levels of the exogenous variables for both elementary and Catholic boards are used as instruments for the contract wage. Together they explain 14% of the variation in the current differenced wage, however only the lagged alternative wages are statistically significant in an equation for the wage. The Chi-square test of the over-identifying restrictions is 2.76 with 5 degrees of freedom. Hence, the overidentifying restrictions are not rejected.

[c] The estimates in the last two columns were obtained using a minimum distance procedure. The standard errors allow for arbitrary heteroskedasticity and autocorrelation. See Hsiao (1986) pgs 104-106. The model was first estimated with different parameters for each year. The parameters were then restricted to

be the same across years, in addition to the over-identifying restriction which is that the ratio of coefficients on pupils must be equal to the ratio of the coefficients on non-instructional costs. The Chi-square statistic is 7.82 with 43 degrees of freedom. Hence the restrictions are not rejected at any reasonable level of confidence. The estimated inverse elasticity of supply from the restricted equations is .178 (.084) and the demand elasticity is -.526 (.511). Computations were done using IML.

Table 3a: OLS Estimates of the Contract Curve and of Reduced Form Equations for Employment and Wages Boards, All Boards, 1976/77-1982/83.

| | Contract Curve | Reduced Forms | |
|---|---|---|---|
| Dependent Variable: | (1) Emp | (2) Emp | (3) Wage |
| Independent Variables: | (Intercepts not shown) | | |
| Wage | .063 | - | - |
| | (.138) | | |
| Alternative Wage | -.838* | -.793* | .727* |
| | (.092) | (.074) | (.039) |
| Local Wage in Manufacturing | -.014 | -.013 | .019 |
| | (.056) | (.056) | (.029) |
| Local Index of Employment | -.054* | -.057* | -.061* |
| | (.020) | (.020) | (.011) |
| Local Average Income | .114* | .121 | .101* |
| | (.071) | (.071) | (.039) |
| Local Average Tax Paid | -.121* | -.123* | -.039 |
| | (.041) | (.041) | (.022) |
| Local Total Tax Paid | .080* | .080* | -.001 |
| | (.015) | (.015) | (.008) |
| Number of Pupils | .770* | .774* | .063* |
| | (.024) | (.023) | (.010) |
| Non-Instructional Costs | .031 | .030 | -.010 |
| | (.015) | (.014) | (.007) |
| Degrees of Freedom | 1374 | 1375 | 1375 |
| SSE | 1.61 | 1.61 | .464 |
| R-square | .618 | .618 | .717 |

Notes:

All variables are in deviations from their 75/76-82/83 board means. Standard errors corrected for arbitrary heteroskedasticity using White's (1980) procedure. * indicates significance at the 95% level.

Table 3b: OLS Estimates of the Contract Curve and of Reduced Form Equations for Employment and Wages for Boards with Decreasing Enrollments, and those with Increasing Enrollments: 1976/77-1982/83.

| | Decreasing Enrollments | | | Increasing Enrollments | | |
|---|---|---|---|---|---|---|
| | Contract Curve | Reduced Forms | | Contract Curve | Reduced Forms | |
| Dependent Variable: | (1) Emp | (2) Emp | (3) Wage | (4) Emp | (5) Emp | (6) Wage |
| Independent Variables: (Intercepts not shown) | | | | | | |
| Wage | .042 (.069) | - | - | .043 (.138) | - | - |
| Alternative Wage | -.674* (.011) | -.646* (.099) | .687 (.047) | -.908* (.158) | -.874* (.118) | .794* (.073) |
| Local Wage in Manufacturing | -.034 (.060) | -.034 (.060) | .022 (.033) | -.056 (.118) | -.056 (.118) | .002 (.059) |
| Local Index of Employment | -.055* (.023) | -.058* (.023) | -.059* (.012) | -.039 (.041) | -.042 (.040) | -.064 (.025) |
| Local Average Income | .096 (.081) | .102 (.081) | .147* (.044) | .083 (.129) | .083 (.129) | .017 (.082) |
| Local Average Tax Paid | -.099* (.047) | -.102* (.048) | -.067* (.025) | -.107 (.079) | -.107 (.079) | .012 (.046) |
| Local Total Tax Paid | .090* (.019) | .090* (.019) | -.001 (.009) | .050* (.025) | .050* (.025) | -.008 (.015) |
| Number of Pupils | .735* (.032) | .738* (.031) | .068* (.013) | .809* (.043) | .811* (.040) | .035* (.017) |
| Non-Instructional Costs | .021 (.015) | .021 (.015) | -.011 (.008) | .025 (.022) | .024 (.020) | -.015 (.014) |
| Degrees of Freedom | 1040 | 1041 | 1041 | 320 | 321 | 321 |
| SSE | 1.07 | 1.07 | .337 | .467 | .467 | .121 |
| R-square | .614 | .614 | .708 | .619 | .619 | .744 |

Notes:
All variables are in deviations from their 75/76-82/83 board means. Chow tests for the equality of the coefficients for boards with increasing and decreasing enrollments are 6.46 for the contract curve equation, 7.19 for the employment equations, and 1.98 for the wage equation. The critical at the 95% level of confidence is 1.98. * indicates significance at the 95% level.

References:


Abowd, John. Collective Bargaining and the Divison of the Value of the Enterprise", Working Paper #218, Industrial Relations Section, Princeton University.

Azariadis, Costas. "Implicit Contracts and Underemployment Equilibrium", Journal of Political Economy, 83, 1975.

Baily, M. "Wages and Employment under Uncertain Demand," Review of Economic Studies, 41, 1974.

Bean, C., Gavosto, A., Oswald, A. and Turnbull, P. Wages and Employment Determination in the Docks," mimeo, Centre for Labour Economics, London School of Economics, 1987.

Bean, C. and Turnbull, P., Employment in the Coal Industry: A Bargaining Approach," Centre for Labour Economics Working, London School of Economics, Working paper #830, 1986.

Brown, James and Orley Ashenfelter. "Testing the Efficiency of Employment Contracts" JPE 94 (June 1986).

Card, David. "Efficient Contracts with Costly Adjustment" American Economic Review 76 (Dec 1986).

Card, David. "Unexpected Inflation, Real Wages, and Employment Determination in Union Contracts", preliminary draft, May 1988.

Christofides, Louis and Andrew Oswald. Efficient and Inefficient Employment Outcomes: A Study Based on Canadian Contract Data, mimeo, Centre for Labour Economics, London School of Economics, 1988.

Doiron, D.J. Wage and Employment Contracts as Equilibria to a Bargaining Game: An Empirical Analysis, mimeo, University of Western Ontario, 1987.

Easton, Todd. "Bargaining and the Determinants of Teacher Salaries", Industrial and Labor Relations Review, V. 41 Jan. 1988.

Eberts, Randall and Joe Stone. "On the Contract Curve: A Test of Alternative Models of Collective Bargaining", Journal of Labor Economics 4 1986.

Ehrenberg, Ronald and Orley Ashenfelter. "The Demand for Labor in the Public Sector", in Labor in the Public and NonProfit Sectors, Daniel Hammermesh ed., 1975.

Frey, Donald, "Wage Determination in Public Schools and the Effects of Unionization", in Labor in the Public and NonProfit Sectors, Daniel Hammermesh ed., 1975.

Hsiao, Cheng, "Analysis of Panel Data", Cambridge University Press, 1986.

Johnson, George. "Work Rules, Featherbedding, and Pareto-Optimal Union-Management Bargaining", mimeo (Feb.1985).

Landon, John and Robert Baird. "Monopsony in the Market for Public School Teachers", AER 61 (Dec 1971).

Lipsky, David and John Drotning. "The Influence of Collective Bargaining on Teachers' Salaries in New York State", Industrial and Labor Relations Review 27 (Oct 1973).

Luizer, James and Robert Thornton. "Concentration in the Labor Market for Public School Teachers", Industrial and Labor Relations Review, Vol 39 July 1986.

MaCurdy, Thomas and John Pencavel. "Testing Between Competing Models of Wage and Employment Determination in Unionized Markets", JPE 94 (June 1986).

McDonald, I. and Solow, R. "Wage Bargaining and Employment," The American Economic Review, 71, 1981.

Martinello, F. Wage and Employment Determination in a Unionized Industry: The IWA in the BC Wood Products Industry, mimeo, Carleton University.

Neelin, Janet. "Collective Bargaining in the Public Sector: Three Studies", Doctoral Dissertation, Princeton University, 1988, Chapt. 3.

Oswald, Andrew. "Efficient Contracts are on the Labour Demand Curve: Theory and Facts", Industrial Relations Section Princeton University Working Paper #178 (July 1984).

Sullivan, Daniel. "Estimates of Monopsony Power in the Market for Hospital Workers", mimeo 1986.

Svejnar, Jan. "Bargaining Power, Fear of Disagreement and Wage Settlements: Theory and Evidence from US Industry," Econometrica, 54, 1986.

Nickell, Stephen and Sushil Wadhwani, "Financial Factors, Efficiency Wages and Employment: Investigations using UK Micro-Data". LSE Working Paper #993, Nov. 1987.

White, Halbert. "A Heteroskedasticity-Consistent Covariance

Matrix Estimator and a Direct Test for Heteroskedasticity", Econometrica 48 (1980).

Woodbury, Stephen. "The Scope of Bargaining and Bargaining Outcomes in the Public Schools", ILRR 38 (Jan 1985).

Appendix 1: Data Sources.

| Name | Description | Source |
|---|---|---|
| Employment | "Full time Equivalent Teachers" including those attached to central office. | Education Relations Commission |
| Panel | Elementary, Secondary, or Catholic. | ERC |
| Pupils | Full time Equivalent Enrollment. | ERC |
| Pupil/Teacher Ratio | Employment/Pupils. | ERC |
| Wage | Maximum Salary in each District. | ERC |
| Labor Disputes | Occurence of strikes, arbitrations, Anti-Inflation Board rulings and legislated settlements. | ERC Annual Report 83/84, ERC monograph #27, Collective Bargaining Review, and Collective Bargaining Settlements in Ont. |
| Non-Instructional Costs | Total expenditure per per pupil less instructional costs per pupil. | Ontario Ministry of Education. |
| Instructional Costs | Salaries, materials, some benefits, secretarial support, principals salary, etc. | OME |
| Consumer Price Index:Canada | Measured in Sept. 1981=100 | Statistics Canada 1984 University Base, series #D130000 |
| Ontario Average Real Wage | Average weekly wages and salaries x 50 deflated by CPI. | Statistics Canada 1983 University Base, series #D1501 |
| Local Total Tax Paid | Total federal and provincial tax payable for 39 cities. | Revenue Canada |
| Local Average Tax Paid | Total tax divided by number of returns. | Revenue Canada |

| | | |
|---|---|---|
| Local Average Income | Average income from tax returns for 39 cities. | Revenue Canada |
| Local Employment Index | Employment index for 35 cities, 1961=100 | Canada Year Book |
| Local Average Wage | Average weekly wages and salaries for 35 cities x 50, deflated by the CPI. | Canada Year Book |

Appendix 1
Table 1: Variable Means by Year and Panel, All Observations.
(1=Elementary, 2=Secondary, 3=Catholic Schools, N=1600)

| Variable: | Panel: | 75/76 | 76/77 | 77/78 | 78/79 | 79/80 | 80/81 | 81/82 | 82/83 |
|---|---|---|---|---|---|---|---|---|---|
| Real Maximum Wage | 1 | 37600 | 38535 | 37885 | 36954 | 36220 | 35898 | 35245 | 35398 |
| | 2 | 37871 | 38862 | 38289 | 37586 | 36685 | 36437 | 35730 | 35768 |
| | 3 | 36449 | 37117 | 36613 | 36080 | 35481 | 35171 | 34614 | 34887 |
| Real Hourly Wage in Manufacturing | - | 16462 | 17503 | 17712 | 17341 | 16990 | 16983 | 16420 | 16631 |
| Local Average Wage | - | 16887 | 17873 | 17919 | 17362 | 17241 | 17161 | 16724 | 16538 |
| Local Average Income | - | 15157 | 15707 | 15562 | 14188 | 14129 | 14823 | 14772 | 14560 |
| Number of Pupils | 1 | 12228 | 11843 | 10680 | 10278 | 10003 | 9795 | 9636 | 9493 |
| | 2 | 8050 | 8062 | 8005 | 7855 | 7663 | 7426 | 7315 | 7218 |
| | 3 | 8772 | 8749 | 8167 | 8148 | 8124 | 8166 | 8239 | 8301 |
| Employment | 1 | 585 | 576 | 558 | 543 | 537 | 536 | 539 | 536 |
| | 2 | 478 | 481 | 481 | 476 | 468 | 464 | 459 | 461 |
| | 3 | 423 | 425 | 430 | 435 | 434 | 444 | 450 | 457 |
| Local Employment Index | - | 147 | 152 | 155 | 155 | 158 | 158 | 162 | 150 |
| Pupil/Teacher Ratio | 1 | 20.9 | 20.3 | 18.9 | 18.6 | 18.3 | 18.1 | 17.6 | 17.5 |
| | 2 | 16.9 | 16.8 | 16.6 | 16.4 | 16.2 | 15.8 | 15.7 | 15.3 |
| | 3 | 20.3 | 20.0 | 18.5 | 18.3 | 18.2 | 18.1 | 17.9 | 17.7 |
| Instruction: Real per Pupil Expenditure | 1 | 2207 | 2378 | 2296 | 2177 | 2017 | 1875 | 1687 | 1651 |
| | 2 | 3545 | 3658 | 3449 | 3133 | 2864 | 2608 | 2347 | 2313 |
| | 3 | 2136 | 2316 | 2228 | 2098 | 1947 | 1797 | 1596 | 1529 |
| Non-Instructional Costs per Pupils (real) | 1 | 759 | 719 | 747 | 754 | 757 | 790 | 827 | 792 |
| | 2 | 1024 | 977 | 1004 | 966 | 948 | 1000 | 1029 | 1041 |
| | 3 | 765 | 770 | 781 | 785 | 790 | 841 | 830 | 843 |
| Local Average Tax Paid ($1000.) | - | 2.45 | 2.50 | 2.42 | 2.11 | 2.15 | 2.32 | 2.39 | 2.37 |
| Local Total Tax Paid ($1000,000) | - | 551 | 505 | 478 | 462 | 449 | 470 | 479 | 491 |

**Appendix 2**

Table A1: Two-Stage Least Squares Estimates of Supply and Demand: 1975/76-1982/83.
(All Variables Measured in Deviations From Board Means).

| | Dependent Variable=Employment | |
|---|---|---|
| | Demand | Supply |
| Independent Variables: (Intercepts not shown) | | |
| Wage | -1.19 | 10.18* |
| | (.098) | (1.29) |
| Alternative Wage | - | -7.99 |
| | | (1.11) |
| Average Income | - | -.405 |
| | | (.155) |
| Local Wage in Manufacturing | .310* | -.500 |
| | (.062) | (.262) |
| Local Employment Index | -.158* | .723* |
| | (.025) | (.138) |
| Local Average Tax Paid | -.072* | - |
| | (.020) | |
| Local Total Tax Paid | .091* | - |
| | (.017) | |
| Number Pupils | .784* | - |
| | (.023) | |
| Non-Instructional Costs | .021 | - |
| | (.012) | |
| Degrees of Freedom | 1499 | 1499 |
| Sum Sq. Errors | 2.84 | 59.30 |
| R-square | .521 | .046 |

Notes:

Chi-square for the over-identifying restrictions on demand is 3 with 1 degree of freedom (critical value=3.84). Chi-square for the over-identifying restrictions on supply=5.1 with 3 degrees of freedom (critical value 7.81). Hence, the overidentifying restrictions are not rejected. * indicates significance at the 95% level.

Table A2: Two-Stage Least Squares Estimates of Demand and Supply: 1975/76-1982/83.
Differences Elementary and Secondary Boards.
All Variables Measured in Deviations From Board Means.
Dependent Variable=Employment.

| | (1) Demand | (2) Supply |
|---|---|---|
| Independent Variables: (Intercepts not shown) | | |
| Wage | -.858* | 11.88* |
| | (.147) | (2.88) |
| Alternative Wage | - | -8.09* |
| | | (2.10) |
| Number Pupils | .602* | - |
| | (.030) | |
| Non-Instructional Costs | .012 | |
| | (.033) | - |
| Degrees of Freedom | 578 | 579 |
| Sum Sq. Errors | 1.20 | 31.63 |
| R-square | .451 | .030 |

Notes:

From Table 3, column (4) one can see that the instruments explain 43% of the variation in the differenced wage. The Chi-squared test of the over-identifying restriction on the supply curve is .23, hence the restriction is not rejected.

Table A3: Estimates of the Contract Curve and Reduced Forms of the Supply/Demand System: 1975/76-1982/83. Differences Between Elementary and Catholic Boards. (All Variables Measured in Deviations From Board Means).

| | Contract Curve | | Reduced Forms Demand/Supply | | | |
|---|---|---|---|---|---|---|
| | OLS[a] | 3SLS[b] | OLS | | Restricted[c] | |
| Dependent Variable: | (1) Emp. | (2) Emp. | (3) Emp. | (4) Wage | (5) Emp. | (6) Wage |
| Independent Variables: | (Intercepts not shown) | | | | | |
| Wage | .073 (.071) | -.790* (.325) | - | - | - | - |
| Alternative Wage | -.475* (.134) | -.499* (.221) | -.458* (.134) | .238* (.082) | -.177 (.745) | .232 (.356) |
| Number Pupils | .888* (.025) | .870* (.030) | .888* (.027) | .004 (.016) | .815* (.143) | -.010 (.069) |
| Non-Instructional Costs | .023* (.020) | .022 (.024) | .023 (.021) | -.009 (.014) | .014 (.077) | - |
| Degrees of Freedom | 428 | 383 | 429 | 429 | 429 | 430 |
| Sum Sq. Errors | .687 | .712 | .689 | .337 | | |
| R-square | .772 | | .771 | .027 | | |

Notes:

a All OLS estimates are corrected for arbitrary heteroskedasticity using White's (1980) procedure. * indicates significance at the 95% level of confidence.

b Computed using the estimated covariance matrix from a 2SLS regression to correct for heteroskedasticity. See Neelin (1988) for details. Lags of the levels of the exogenous variables for both elementary and Catholic boards are used as instruments for the contract wage. Together they explain 8% of the variation in the current differenced wage. The Chi-square test of the over-identifying restrictions is 2.1 with 5 degrees of freedom. Hence, the overidentifying restrictions are not rejected.

c The estimates in the last two columns were obtained using a minimum distance procedure. The standard errors allow for arbitrary heteroskedasticity and autocorrelation. See Hsiao (1986) pgs 104-106. The model was first estimated by OLS with different parameters for each year. The parameters were then restricted to be the same across years, in addition to the overidentifying restriction. The overidentifying restriction is

that the ratio of coefficents on pupils is equal to the ratio of coefficients on non-instructional costs. The Chi-square statistic is 3.38 with 43 degrees of freedom. Hence the restrictions are not rejected at any reasonable level of confidence. The estimated inverse elasticity of supply from the restricted equations is -.012 (.084) and the demand elasticity is -.763 (3.81). Computations were done using IML.

Table A4: Two-Stage Least Squares Estimates of Demand and Supply: 1975/76-1982/83.
Differences Elementary and Catholic Boards.
All Variables Measured in Deviations From Board Means.
Dependent Variable=Employment.

| | (1) Demand | (2) Supply |
|---|---|---|
| Independent Variables: (Intercepts not shown) | | |
| Wage | -1.92* | 23.22 |
| | (.766) | (33.14) |
| Alternative Wage | - | -5.11 |
| | | (8.22) |
| Number Pupils | .896* | - |
| | (.041) | |
| Non-Instructional Costs | .006 | - |
| | (.032) | |
| Degrees of Freedom | 429 | 430 |
| Sum Sq. Errors | 2.03 | 183.39 |
| R-square | .534 | .001 |

Notes:

From Table 2, column (4) one can see that the instruments explain only 3% of the variation in the differenced wage. The Chi-squared test of the over-identifying restriction on the supply curve is 4.6, hence the restriction is rejected.