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UNIONIZATION AND PRODUCTIVITY IN OFFICE BUILDING AND SCHOOL CONSTRUCTION

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Abstract

This paper examines the difference in productivity between union and nonunion contractors in the construction industry over a sample of 83 commercial office buildings and another sample of 68 elementary and secondary schools. The popular belief that the building trades unions reduce productivity in the industry is soundly rejected in both samples. Square footage per manhour is 38 percent higher in office buildings built predominantly by union labor, controlling for differences in capital-labor ratios, observable labor quality, region, and building characteristics. Estimates of the union-nonunion productivity difference in the school sample range from zero (when output is measured in physical units) to 20 percent greater for union contractors (when output is measured as value added deflated by regional price differences), controlling for the same factors.

Possible sources of higher union productivity in the office building sample are explored. A lower ratio of supervision to production worker hours and use of technologies and materials that economize on labor account for as much as 25 percent of the higher productivity observed in the union sample. The remainder is probably attributable to apprenticeship training, unobserved labor quality, economies of recruiting and screening, and improved manangement.

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Introduction

A number of recent controversial studies have found productivity is frequently higher in union establishments than otherwise identical nonunion establishments in the same industry.[1] So far critics such as Addison have used two types of arguments to claim none of these studies really show higher productivity in the union sector.[2] First, data limitations are severe enough in each study to leave lingering doubts about the results. For instance when productivity is measured in terms of value added, cross section deflators are needed to distinguish between price and output differences. Some studies do not deflate at all, while in others the deflators are far from ideal. With better deflators, these union productivity effect estimates could have been much lower. Also, broad geographic and industry aggregates are used in many of these same studies, which may mask considerable market segmentation and again bias estimates upward. Second, the sources of the estimated union productivity advantage remain largely unidentified. In construction the occupational mix and apprenticeship programs accounted for no more than 27 percent of the estimated union productivity advantage. In manufacturing, Brown and Medoff could only identify lower turnover as a source of higher union productivity.

This paper attempts to add to our understanding of the union productivity effect by examining two rather unique data sets: one sample of 83 commercial office buildings and another of 68 elementary and secondary school buildings. These data sets have the advantage that output can be measured in terms of physical units--square feet of space and, in the school sample, student capacity and classrooms. When the dependent variable is expressed in physical units instead of value added, the union coefficient in the production function can be interpreted solely as a productivity effect, not as a wage effect.[3] Also, there will not be any aggregation bias in these estimates because the units of observation are separate construction projects, rather than state or regional totals containing various types of structures and markets with various levels of unionization.

The sources of estimated union-nonunion productivity differences can also be examined in greater depth with these two data sets. Hours worked are reported by detailed occupational categories with separate entries for journeymen and apprentices. Separate totals can be calculated for skilled trades, operating engineers, semiskilled and unskilled workers, and administrative and supervisory workers. Two routes by which unions allegedly alter the occupational mix to change productivity--raising the ratio of skilled to unskilled production hours and lowering the ratio of supervisory to production hours--can then be isolated. Each data set also provides some background information on the general contractor for each project, such as annual volume and the extent to which he specializes in a particular type of construction. This should provide better controls for entrepreneurial efficiency. In the office building sample each contractor was asked whether strikes, weather, building codes, skilled labor supply, apprenticeship programs, and prefabricated or standardized components had any effect (positive, zero, or negative) on productivity during construction of the building. The influence of these factors on the union productivity effect can be gauged by incorporating the contractors' impressions as separate variables in the quantitative analysis.[4]

Although the focus in this paper is on union-nonunion differences, the results also shed some new light on productivity measurement issues in construction. Researchers have shied away from attempting to develop measures based on physical units because of the allegedly extreme heterogeneity of the product.[5] While this issue will be explored more carefully in subsequent work, the results reported here indicate that in at least one of the two samples heterogeneity may not distort productivity comparisons as much as previously thought.

How Do Unions Affect Productivity in Construction?

I have discussed the mechanisms through which unions influence productivity in the construction industry elsewhere and will provide only a brief summary here.[6] Basic price theory predicts observed labor productivity will be higher in the union sector because higher union wage rates lead employers to screen workers more carefully to obtain higher quality labor and to substitute other inputs for labor in the production process. This is allocatively inefficient, however, because buildings could be constructed at lower cost if the union wage effect were zero. Without careful controls for these adjustments, the institutional effect of unionism cannot be distinguished from the price theoretic effect of higher union wages.

The overall institutional effect of the building trades unions on productivity may be either positive or negative. Even though most union members receive their training from other sources, the apprenticeship programs in the union sector create a core of well-rounded journeymen that has no counterpart in the open-shop sector. Unless these highly skilled tradesmen spend much of their time doing simple tasks, this should provide the union sector with more human capital per production worker hour and higher productivity. Also, since thoroughly trained workers require much less assistance and monitoring, there is less need for supervision on union job sites. Union hiring halls can also serve to increase efficiency when large numbers of workers are needed by making adequate supplies of labor available on relatively short notice. Interview evidence indicates that many open-shop contractors do not bid on larger projects because of the risk of being unable to find enough workers. In addition, reduced uncertainty about labor supply permits management to plan projects and schedule work assignments more efficiently. The halls also screen workers, reducing uncertainty about labor quality in a market predominated by short term relationships between individual workers and contractors. Offsetting these employer search economies are potential restrictions on the contractor's choice of workers when contract provisions are being strictly enforced. A final route through which unionism could serve to raise productivity in the construction industry is the behavior of management. In order to maintain profits in the face of increased wages, managers may change organizational practices, such as materials management, quality control, cost estimating, or work scheduling methods in an attempt to squeeze more output out of the same quantity of nonmanagerial inputs.

Other union practices work in the opposite direction. The most frequently cited indicators of lower productivity in the union sector are work rules which restrict contractors from using certain types of tools or equipment or force them to hire more workers than necessary to do a job. Another institutional factor which places union contractors at a comparative disadvantage is the craft jurisdiction system which assigns each task to a particular craft union. This reduces the union contractor's flexibility in making work assignments and is a non-negligible source of work stoppages. While there is evidence these rules and customs are not always enforced (and the probability of enforcement is itself a function of the overall state of labor-management relations), they can potentially offset or override the factors which enhance productivity in the union sector.

Note these mechanisms are quite distinct from those in manufacturing, where previous studies of the union productivity effect have focused. One of the primary sources of higher union productivity in that sector is reduced turnover. In construction there are only short term attachments between workers and employers. This puts a premium on minimizing search and screening costs per hire via improved information about job vacancies and reduced qualitative uncertainty about new hires as opposed to minimizing the number of persons hired via lower quit rates. The argument that union seniority systems reduce worker rivalry and increase cooperation and informal training also is not very applicable in construction. Instead the impetus toward more training in the building trades comes from craft traditions and formal apprenticeship systems. Two other mechanisms emphasized in the manufacturing sector--increased managerial efficiency and improved communication between workers and management--should apply to construction.

Another important difference between construction and manufacturing is the magnitude of the union wage effect. The OLS estimates in Allen using the May 1973-75 Current Population Survey (CPS) showed union wages in construction across all occupations were 54 percent higher than those for nonunion workers with identical observable characteristics. In contrast, using a more or less identical model for manufacturing over the same data source the union wage effect is between 10 and 20 percent.[7] If union contractors are to compete effectively with the open-shop, the union productivity effect must be much larger in construction than in manufacturing.

The union wage effect can be estimated for both samples of buildings by regressing average hourly earnings for each occupation group for each contractor on union status, occupation dummies (74 in the office building sample, 55 in the school sample), SMSA status, and three region dummies. The results are as follows:

Sample	Union status regression coefficient	Standard error	Union wage effect
Office buildings	.297	.008	34.6%
Schools	.201	.010	22.2%

These are considerably smaller than the CPS estimates. The main reasons for this are the degree of occupational detail and the limitation of the samples to particular types of construction. If age and schooling data were available, these estimates would probably be even smaller.[8] The omission of fringe benefits produces a bias in the opposite direction.

Empirical Model

Assume that the production function for commercial office buildings and elementary and secondary schools is Cobb-Douglas and is written

$$Q_i = AK_i^{\alpha}L_i^{\beta}, \quad (1)$$

where Q_i = output (measured in terms of value added, square feet, classrooms, or student capacity), A = a constant reflecting organizational factors and building characteristics, K_i = capital input, L_i = labor input, α = elasticity of output with respect to capital, and β = elasticity of output with respect to labor.[9] Dividing each side of (1) by L_i and taking logs produces the conventional estimating equation

$$\ln(Q_i/L_i) = \ln A + \alpha \ln(K_i/L_i) + (\alpha+\beta-1) \ln L_i, \quad (2)$$

where $(\alpha+\beta-1)$ measures returns to scale. The impact of unionization through price-theoretic routes is measured in terms of changes in K_i/L_i and the quality-adjustment of L_i. In order to measure the organizational and labor-relations impact of unionization on productivity, let $A = A_n$ for nonunion contractors and $A = A_n(1+b)$ for union contractors, where b is the percentage change in productivity resulting from unionization. Then (2) can be rewritten

$$\ln(Q_i/L_i) = \ln A_n + bU_i + \alpha \ln(K_i/L_i) + (\alpha+\beta-1) \ln L_i \quad (3)$$

where U_i is a binary variable equal to one for projects built with 50 percent or more union labor.[10] This specification does not assign the union productivity effect to either labor or capital. If the effect operates solely through labor, then b must be divided by β to get a measure directly comparable to the union effect on wages. Note also that the union productivity effect could operate through α or β, i.e., that these terms may be different for union and nonunion contractors. In this case (3) should be written

$$\ln(Q_i/L_i) = \ln A_n + bU_i + \alpha_n \ln(K_i/L_i) + (\alpha_u - \alpha_n) \ln(K_i/L_i)U_i + (\alpha_n+\beta_n-1) \ln L_i + (\alpha_u+\beta_u-1) \ln L_i U_i. \tag{4}$$

Both data sets were gathered as part of the BLS Construction Labor and Material Requirements series.[11] The school survey was conducted in 1972; commercial office building, in 1974. In each survey the general contractor was asked to provide information on the total value of the contract, building characteristics, building materials, construction dates, and factors that affected productivity. The general contractor and each subcontractor also provided data on the type and cost of each material item, fair rental value or depreciation for each type of equipment, and hours and wages for each occupation used for onsite labor.

Different types of capital expenditure data were provided in the two surveys. In the school survey, each contractor for each project was asked to provide the rental cost, the allowance by the contractor for owned equipment, or the equivalent of rental cost for each type of equipment. In addition, the number of hours operated is also reported for each. The sum of all capital equipment expenditures for all contractors on a particular project is used here as the capital measure for schools. (The sum of all hours operated was also examined, but produced essentially the same results.) In the office building survey, each contractor provided equipment expenditure information (depreciation or rental cost), as well as the interest expense incurred on money borrowed for the contract. The sum of these two sets of expenses for all contractors for a particular office building is the capital measure for this sample. Offsite capital (e.g., structures, office furniture and equipment) is not reported.

Labor input in each sample equals total onsite hours worked for all occupations. Virtually all of this represents production labor. The only nonproduction categories reported are clerical workers (e.g., timekeepers), professional and technical workers (e.g., draftsmen, engineers), and foremen. No offsite labor input information is provided. If offsite labor (or capital) can be substituted for onsite labor (or capital), this omission may bias the results. For instance, if more units of management are used per onsite labor hour in union (nonunion) projects, this will bias the estimate of b upward (downward). Nothing in the institutional literature on union or open-shop construction indicates that such a bias is likely. Nonetheless, the general contractor's 1974 dollar volume in private office building construction is used as an independent variable in some specifications reported below as a proxy for offsite inputs.

The only observable indicator of labor quality for each project is the occupational distribution. Workers from 75 different occupational categories were used in the office building sample; 56 in the school sample. Separate totals are reported for journeymen and apprentices. This information is converted into a labor quality index for each building (O_i) by the formula

$$O_i = \sum_j \bar{y}_j L_{ij} / \sum_j L_{ij}, \tag{5}$$

where L_{ij} = hours worked on project i by occupation j and $\bar{y}_j$ is 1969 median earnings for males in occupation j.[12] The index represents the predicted annual income for the labor force on a particular project and is positively related to skilled labor intensity. Three region dummies and an SMSA dummy are added to further control for differences in labor quality (and production technology) across geographic locations.

A final set of variables is needed to control for building characteristics and materials. Each project in each sample is designed to meet the particular needs of its buyer, so designs are likely to vary considerably. Some buildings in each sample are likely to have distinctive designs and numerous amenities; others are likely to be "no-frills" structures. This makes interpretation of (3) difficult because of possible correlation between unionization and design characteristics which influence output per manhour. For instance, suppose union (nonunion) contractors tend to specialize in "no-frills" structures which can be completed with less labor input per square foot than those with more design amenities. Then failure to control for these design characteristics upwardly (downwardly) biases the union coefficient.

The frequency distributions in Table I for selected building characteristics show some sizable union-nonunion differences are present. The most striking difference is in the size of the buildings. Over half of the nonunion office buildings are single story structures, in contrast to one fourth of the union sample. Over a quarter of the union office buildings are more than 10 stories tall, in contrast to none of the nonunion buildings. Nonunion schools also tend to be smaller than union schools.[13]

The choice of building materials varies with unionization in some cases. Union office buildings are most likely to have steel frames; nonunion, wood frames. However, steel frames predominate in both union and nonunion schools and appear more frequently in the nonunion sample. Labor cost per square foot tends to be lowest in buildings with a steel frame.[14] Without controlling for this characteristic, the union coefficient will be biased upward in the office building sample; downward in the school sample. Wooden and precast concrete exterior walls tend to have the lowest labor cost per square foot, followed by

Table I. Frequency distribution of selected building characteristics, by type of building and union status

Building characteristic	Office buildings Union	Office buildings Nonunion	Elementary and secondary schools Union	Elementary and secondary schools Nonunion
Stories				
1	25	53	63	73
2 or 3	34	37	37[a]	27[a]
4 to 10	12	10	-	-
11 to 35	20	-	-	-
36 to 60	8	-	-	-
Frame				
Steel	53	26	63	82
Concrete	25	0	12	-
Masonry	11	21	16	9
Wood	11	53	9	9
Exterior wall				
Masonry	48	63	82	100
Curtain wall	-	-	2	-
Concrete	23	16	5	-
Wood	5	16	2	-
Other	23	5	9	-
Roof base				
Steel decking	39	37		
Concrete	38	10		
Wood/plywood	22	53		
Other	2	-		
Interior wall				
Dry well	84	89	39	27
Plaster	6	11	12	18
Metal	-	-	7	9
Movable partitions	3	-	-	-
Other	6	-	42	45
Floor base				
Concrete	92	74	93	100
Wood/plywood	8	26	4	-
Other	-	-	4	-

Source: BLS Labor and Material Requirements Surveys.

[a]The category for the school sample is actually 2 to 4 stories.

masonry and poured concrete.[15] The roof base in union office buildings is most likely to be steel or concrete; in nonunion office buildings, steel or wood. The effect of these differences on the union coefficient cannot be assessed ex ante.[16] Union-nonunion differences in interior wall and floor base materials are less pronounced and thus less likely to bias the estimates.

The simplest way to control for building characteristic differences across buildings is to include dummy variables in (3) corresponding to each characteristic, making the intercept a function of the characteristics. This cannot be done for three reasons. First, there are almost as many characteristics reported in each survey as there are observations. Second, some of the characteristic coefficients have implausible values, presumably because of collinearity with other characteristics or inadequate sample variation. This signals a serious specification error which can be compounded if the magnitude of the estimate of α, β, or b is sensitive to the inclusion of the variable in question. Third, some of the characteristics are observed in only one building, clouding the interpretation of the coefficient--does it represent the effect of the characteristic or the idiosyncracies of a particular building?

The following decision rules were followed to determine which building characteristics were included in the estimated equations. First, the characteristic had to appear in more than one building in a particular sample. Second, the sign of the coefficient had to be consistent with engineering data. The 1977 Dodge Construction Systems Costs manual reports labor cost per square foot for most building characteristics reported. Characteristics with positive (negative) coefficients were not included if they tended to raise (lower) labor cost per square foot. If a sign prediction was unavailable, a variable was included if it lowered the estimate of b. This stacks the deck against the hypothesis that productivity is higher in the union sector. Third, either the coefficient of the characteristic had to be larger than its standard error or the magnitude of the α, β, or b estimates had to be sensitive to the inclusion of the characteristic in the equation. Inclusion of additional characteristics would bias the standard errors of coefficients upward. If this rule were not followed, there would not be enough degrees of freedom available to test hypotheses. The sensitivity of the results to alternate regression strategies, including omission of all building characteristics, will also be discussed.

Empirical Results: Commercial Office Buildings

Two different measures of productivity are used for the office building sample: value added per manhour and square feet per manhour. The former is the standard measure of productivity used by economists and reported in the national income accounts. The problems with using it to make union-nonunion productivity comparisons, mentioned above, are discussed in greater detail elsewhere.[17] Despite probable upward bias, I report value added per manhour results so they can be compared to those obtained using a more appropriate productivity measure, square feet per manhour. This is a variation of the standard productivity (actually unit labor cost) measure used in the industry, cost per square foot. As long as design characteristics can be held constant, valid productivity comparisons can be made across union and nonunion projects using square feet per manhour in residential and most types of commercial construction.

The sample, union, and nonunion means of the two productivity measures are reported in Table II. For each measure productivity is roughly 50 percent higher in the union sample. This is not surprising, given the substantial difference in the capital-labor ratios and the smaller but nontrivial difference in the skill mixes. The key issue is whether, once one controls for these two factors as well as for building characteristics, any productivity difference remains.

The following procedure was used to select the building characteristics included in the regressions reported in Table III. First, mean square foot per manhour was calculated for each category of each characteristic. Characteristics showing marked differences by category were included in the initial regressions.

Table II. Descriptive statistics for office building construction, by union status

Variable	Sample mean (N=83)	Union mean (N=64)	Nonunion mean (N=19)
Value added per manhour	15.7 (6.9)	17.0 (7.2)	11.2 (3.0)
Square feet per manhour	1.297 (.785)	1.406 (.841)	.930 (.386)
Capital-labor ratio	.944 (1.587)	1.054 (1.786)	.574 (.337)
Labor quality index	7340 (398)	7417 (363)	7082 (411)

Note: Standard deviations are reported in parentheses below each mean.

Table III. Production function estimates, commercial office buildings

Column: Output measure:	1 Value added	2 Value added	3 Value added	4 Square feet	5 Square feet	6 Square feet
Constant	1.237 (5.715)	10.200 (6.320)	9.631 (6.321)	-6.874 (9.190)	8.724 (9.309)	7.089 (9.484)
log (K/L)	.211 (.047)	.221 (.051)	.229 (.051)	.194 (.075)	.133 (.075)	.117 (.077)
log (L)	-.034 (.021)	.024 (.047)	.009 (.048)	-.118 (.034)	-.175 (.070)	-.151 (.072)
Union	.328 (.082)	.411 (.096)	.404 (.097)	.308 (.131)	.319 (.142)	.261 (.146)
Labor quality index	.169 (.650)	-.903 (.717)	-.817 (.719)	.916 (1.046)	-.787 (1.056)	-.651 (1.079)
Northeast	.264 (.102)	.221 (.110)	.179 (.114)	-.167 (.165)	-.174 (.163)	-.213 (.170)
North Central	.228 (.085)	.218 (.097)	.164 (.098)	.145 (.136)	.241 (.143)	.230 (.147)
West	.291 (.100)	.227 (.123)	.158 (.125)	.332 (.161)	.117 (.181)	.154 (.188)
SMSA	.121 (.092)	.143 (.095)	.145 (.093)	.127 (.147)	.156 (.140)	.174 (.140)
Percent interior completed	-.164 (.093)	-.147 (.102)	-.108 (.106)	-.319 (.150)	-.200 (.150)	-.150 (.158)
Steel frame		.183 (.137)	.130 (.142)		.759 (.201)	.857 (.214)
Masonry frame		.121 (.140)	.073 (.140)		.548 (.207)	.554 (.210)
Concrete frame		-.034 (.158)	-.050 (.167)		.482 (.232)	.595 (.250)
Drywall interior		.121 (.121)	.108 (.119)		.241 (.179)	.252 (.179)

Table III (continued)

Column: Output measure:	1 Value added	2 Value added	3 Value added	4 Square feet	5 Square feet	6 Square feet
Movable partitions		.308 (.252)	.153 (.263)		.026 (.371)	.023 (.394)
Other interior wall		-.182 (.192)	-.167 (.188)		-.181 (.283)	-.160 (.283)
Concrete floor base		.003 (.122)	.004 (.120)		-.176 (.180)	-.193 (.180)
Steel roof base		-.204 (.113)	-.186 (.113)		-.386 (.167)	-.428 (.169)
Concrete roof base		-.160 (.127)	-.228 (.132)		-.410 (.187)	-.468 (.198)
Wood roof cover		-.206 (.155)	-.219 (.154)		.047 (.229)	-.016 (.232)
Other roof cover		-.179 (.148)	-.190 (.145)		.494 (.218)	.535 (.218)
Masonry exterior wall			-.016 (.098)			.210 (.147)
Wood exterior wall			-.166 (.144)			-.006 (.216)
Other exterior wall			.164 (.111)			.005 (.167)
2-3 stories		-.001 (.088)	.028 (.090)		.033 (.130)	.074 (.135)
4-10 stories		-.071 (.155)	-.079 (.154)		.078 (.229)	.106 (.231)
11-35 stories		-.172 (.191)	-.154 (.188)		.437 (.281)	.459 (.282)
35-60 stories		-.329 (.256)	-.339 (.253)		.106 (.378)	.147 (.380)

Table III (continued)

Column: Output measure:	1 Value added	2 Value added	3 Value added	4 Square feet	5 Square feet	6 Square feet
Other commercial areas		-.087 (.093)	-.107 (.092)		-.073 (.137)	-.078 (.138)
Air conditioned		-.106 (.117)	-.083 (.116)		-.270 (.173)	-.258 (.174)
Forced air heat		.004 (.078)	-.002 (.076)		-.202 (.114)	-.210 (.114)
σ	.266	.250	.244	.428	.368	.367
R^2	.546	.700	.728	.416	.676	.695
F	9.77	4.75	4.63	5.78	4.24	3.95

Note: Standard errors are reported below each coefficient. The mean (S.D.) of the dependent variable is 2.680 (.373) in columns 1 through 3 and .117 (.528) in columns 4 through 6.

Second, variables were then dropped if they did not meet the criteria outlined in the previous section. Third, a new set of regressions was examined where each of the characteristics previously eliminated and those not previously considered was added to the "core" variables. Separate equations were estimated for each characteristic. Variables were then added or dropped from the "core" category according to the criteria. All variables excluded from the newly defined "core" were then each added separately to the new "core" variables in a new set of regressions. This procedure was repeated until all variables in the core met the criteria and inclusion of any variable outside the core could be rejected along those criteria. This specification is reported in columns 2 and 5 of Table III. To demonstrate the sensitivity of the results to the inclusion of the building characteristics, specifications with all building characteristics omitted are reported in columns 1 and 4.

The key result, reported in column 5, is that productivity, measured in terms of square feet of space built per manhour, is 37.6 percent higher under unionism. If building characteristics are omitted, the estimate falls slightly to 36.1 percent. In contrast the estimates obtained using the value added per manhour measure are 50.8 and 38.9 percent, respectively. The upward bias in the union coefficient that results from use of an undeflated value added measure is as much as 35 percent.

The union coefficient is somewhat sensitive to which building characteristics are included in the estimating equation. When controls for different types of exterior walls are added in columns 3 and 6, the union productivity effect falls slightly to 49.8 percent in the value added specification and declines substantially to 29.8 percent in the square feet specification. However, the coefficients for the exterior wall variables are not consistent with engineering data. Labor costs per square foot are highest for poured concrete walls, followed by masonry, precast concrete, and wood.[18] Labor costs per square foot for other types of exterior walls (metal, stucco, and curtain walls) vary all across this range. Regression coefficients which indicate that productivity is lowest in buildings with wood exteriors are not credible. While exterior wall characteristics do not meet our criteria, these results merit some attention nonetheless as "conservative" estimates of the union productivity effect.

The union coefficient was also quite sensitive to another set of variables which did not meet the criteria for inclusion--type of floor covering. When these variables are included, the union coefficient (S.E.) jumps to .398 (.131), implying a union productivity effect of 49.0 percent. However the floor covering coefficients imply that productivity is lower when floors are covered with carpet or vinyl than when they have terazzo, tile, masonry, concrete, or special finishes. Once again, this makes no sense at all.[19]

Finally, because two different dependent variables were examined, some variables met the criteria for inclusion for one specification, but not the other. If controls for floor base, air conditioning and heating system are dropped from the value added equation in column 2, the union coefficient (S.E.) goes to .412 (.092). If the control for the presence of other commercial areas besides office space is dropped from the square foot equation in column 5, the union coefficient (S.E.) drops to .294 (.133).

The main point which emerges from this analysis is that the key result--that productivity is at least 30 percent greater in the union sector--is quite robust to alternative specifications. Before attempting to account for this result, three points should be noted about the other coefficients. First, the capital-labor ratio, scale, and labor quality coefficients are more sensitive to the inclusion of building characteristics than the union coefficient. This sensitivity reflects the fact that these variables are to a large extent functions of the building characteristics. For instance, a high rise is likely to be more capital and labor quality intensive than a low rise building. Thus once one controls for number of stories, part of the effect of scale and increased capital intensity and labor quality becomes embodied in the height coefficient. The coefficients of α and β may very well be measured more accurately in column 4 than in columns 5 and 6.

Second, there seem to be significant diseconomies of scale in the construction of office buildings. This does not show up in the value added results, probably because increased input costs are counted as output.

Third, the labor quality variable accomplishes very little. It is always very imprecise and is negative when the building characteristics are included in the model.[20] The absence of controls for worker experience is probably the major shortcoming. A measure containing such information may reduce the union coefficient somewhat, since the CPS data used in Allen showed the average age of union construction workers was 38.8; nonunion workers, 34.3. However, when a labor quality variable reflecting union-nonunion differences in age, schooling, occupation, and location was included in Allen it reduced the union coefficient by only 10 percent, so it is doubtful that this omission seriously contaminates the results.

Equation (4) was also estimated to test whether $\alpha_u = \alpha_n$ and $\beta_u = \beta_n$. The coefficient (S.E.) of $(\alpha_u - \alpha_n)$ was .042 (.231), while that of $(\beta_u - \beta_n)$ was -.010 (.053). The F ratio for the joint hypothesis that $(\alpha_u - \alpha_n) \neq 0$ and $(\beta_u - \beta_n) \neq 0$ is .029 with 2 and 53 degrees of freedom. Clearly the null hypothesis that $(\alpha_u - \alpha_n) = (\beta_u - \beta_n) = 0$ cannot be rejected.

In the Cobb-Douglas specification the α estimate should equal capital's share of output. In the 1974 national income accounts this is 22 percent; the 1977 Census of Construction Industries, 34 percent.[21] (Since fringe benefits and offsite inputs are not reported, capital's share in our sample cannot be determined.) The α estimates are below these values, especially in the square feet equations. Since the estimated covariance between α and b is negative, a downwardly biased α estimate means our b estimate is too large. To put the same point differently, union-nonunion differences in capital-labor ratios may not have been totally eliminated in the b estimates reported in Table II. These results cannot be interpreted as total factor productivity effects unless labor and capital inputs are appropriately weighted.

To determine the potential bias in the b estimates, we re-estimated the equations in columns 1, 2, 4, and 5 under the restriction that $\alpha = .34$. The results are as follows:

Specification	Union Coefficient (S.E.)
Value added, building characteristics omitted	.289 (.084)
Value added, building characteristics included	.390 (.099)
Square feet, building characteristics omitted	.263 (.132)
Square feet, building characteristics included	.282 (.149)

These estimates are 10 to 15 percent smaller than those reported in Table II but the key result remains unaffected.

Why is Productivity Higher in Union Office Buildings?

The most likely sources of a 30 percent or more productivity advantage for union labor are superior training, lower supervisory requirements, reduced recruiting and selection costs, and better management in the union sector. How can the impact of these causal forces be quantitatively isolated? The only one of these possibilities for which there is any direct evidence is the occupational mix. This information has already been used to construct the labor quality variable O_i. But since supervisors receive higher wages than skilled construction workers, projects with large supervisory staffs will have higher values of O_i, despite lower labor quality among production workers. To isolate the impact of lower union supervisory requirements, the ratio of supervisor hours to total hours is added to the model. Since this variable is also likely to be correlated with the skill mix of the labor force and O_i did not control for the skill mix very satisfactorily, the ratio of semiskilled and unskilled hours to total hours is also included.

The contribution of contractor characteristics to higher union labor productivity can be indirectly evaluated. Each general contractor was asked to report (1) what percentage of his 1974 dollar volume was for private office buildings, public office buildings, other commercial buildings, and other projects and (2) his 1974 dollar volume of business in private office building construction. This information can identify the effect of contractor specialization in this particular type of construction on productivity. If contractors using union labor are more (less) specialized and this specialization raises productivity, the union coefficient should fall (rise). The latter variable is also a reasonable proxy for offsite capital and labor and can be used to examine whether omission of those inputs biases the estimates in Table III.

Some further indirect evidence about the sources of higher union labor productivity can be obtained from the responses of union and nonunion contractors to a series of questions about the effect of seven factors on productivity in their project: strikes, weather, building codes, apprenticeship programs, prefabricated components, standardized components, and supply of skilled workers. For each factor the contractor reported whether it raised, lowered or had no effect on the employee-hours required to construct the project, as contrasted to any similar projects on which he participated during the past two years.

The responses to this battery of questions by union and nonunion contractors are reported in Table IV. "No effect" was by far the most frequently observed response for any factor in the survey. The factor which seemed to have the biggest impact on hours requirements was the weather. Union projects were more likely to be slowed down by problems with strikes, building codes, prefabricated components, and skilled labor supply and less likely to be slowed down by problems with apprenticeship programs. Interestingly, standardized and prefabricated components were more likely to have raised productivity on union projects, while nonunion contractors were more likely to cite apprenticeship programs and skilled labor supply as lowering hours requirements. This runs counter to the institutional literature surveyed in Allen. Union contractors are allegedly less likely to use prefabricated components because of restrictive work rules, while inadequate training and access to pools of skilled labor supposedly limit the ability of nonunion contractors to compete successfully.

This still begs the question of whether any of these factors really contribute to higher union labor productivity. The contractor responses to the questionnaire may be based upon crude impressions and thus be completely uncorrelated with the actual experience on the project. But if the responses

Table IV. Frequency distributions for factors influencing productivity in commercial office buildings, by union status

Factor	Union status	Percent of projects where factor Raised hour requirements	Lowered hour requirements	Had no effect
Strikes	Nonunion	10	0	90
	Union	14	0	86
Weather	Nonunion	26	5	68
	Union	33	3	64
Building code	Nonunion	0	0	100
	Union	17	2	81
Apprenticeship programs	Nonunion	5	10	84
	Union	2	0	98
Prefabricated components	Nonunion	0	5	95
	Union	5	12	83
Standardized components	Nonunion	0	5	95
	Union	0	14	86
Supply of skilled workers	Nonunion	0	16	84
	Union	9	2	89

Note: Rows may not sum to 100 because of rounding. There are 19 nonunion and 64 union projects.

accurately reflect project conditions, the impact of these factors on union-nonunion productivity differences can be isolated by adding them to the model and observing their effect on the union coefficient.

The impact of variables representing union-nonunion occupational mix differences can be examined in columns 1 through 3 of Table V. While the ratio of supervisor hours to total hours is only slightly higher for nonunion projects (7.7 percent) than for union projects (7.5 percent), adding this variable to the model in column 5 of Table III lowers the union coefficient from .319 to .286, a reduction of 10 percent. There is a much bigger difference between the ratio of semiskilled and unskilled hours to total hours between union (21.8 percent) and nonunion (28.8 percent) projects. However this variable has a slightly smaller impact on the union coefficient, lowering it to .294, a reduction of about 8 percent. Including both variables in the equation lowers the union coefficient to .275, an overall reduction of 14 percent. (Keep in mind that O_i is included in all of these specifications.) Thus, holding overall labor quality (as indexed by O_i) constant, the reduced use of supervisors in union projects accounts for about 10 percent of the union productivity effect.

The results for the skill ratio are more difficult to interpret. On the one hand, since projects with more unskilled workers and the same ratio of supervisor hours to total hours should have lower values of O_i, inclusion of the skill ratio should have no effect on the union coefficient unless the weights used to construct O_i are inappropriate. This may very well be the case here. On the other hand, even if the weights in O_i are accurate (i.e., equal to the average output of each category of workers), can such a variable really capture overall labor quality? The assumption behind the construction of O_i is that labor inputs are strongly separable. If they are not and if unionism has an effect on the

Table V. Production function estimates including factors acting as possible sources of higher union productivity

	1	2	3	4	5	6
Union	.294 (.141)	.286 (.145)	.275 (.145)	.312 (.136)	.295 (.142)	.237 (.139)
Ratio of semiskilled and unskilled hours to total hours	-1.219 (.835)		-1.064 (.873)			-1.247 (.833)
Ratio of supervisor hours to total hours		-.936 (.921)	-.618 (.954)			-.891 (.908)
1974 private office building construction (dollar volume/10^8)				-.721 (.309)		-.768 (.311)
Standardized components helpful					.196 (.146)	.140 (.142)
σ	.364	.367	.366	.354	.365	.346
R^2	.688	.682	.690	.705	.686	.733
F	4.25	4.13	4.08	4.62	4.22	4.52
Percent of union productivity effect explained by model	7.8	10.3	13.8	2.2	7.5	25.7

Note: Each equation contains the same independent variables as those in Table II, col. 5. The dependent variable is log (square feet/hours).

occupational structure independent of the union wage effect (e.g., the craft tradition), then the skill ratio results could also be interpreted as showing another way in which unionism raises productivity.

The contractor specialization variable which has the biggest impact on the union coefficient is the ratio of 1974 dollar volume in projects other than commercial buildings to 1974 dollar volume. The coefficient (S.E.) of this variable (not reported in Table V) is -.326 (.181), a fairly reasonable result. But the union coefficient (S.E.) increases to .393 (.145) when this variable is included. The other variables representing the share of 1974 dollar volume in various types of buildings either have no effect on the union coefficient (public and private office buildings) or increase it slightly (other commercial buildings). It thus seems unlikely that any portion of the higher union productivity can be attributed to specialization of union contractors in the construction of commercial office buildings.

A somewhat different picture emerges when one controls for the general contractor's 1974 dollar volume in commercial office building construction. This is roughly eight times larger for the average union general contractor ($11.8 million) than the average nonunion general contractor ($1.4 million). When this variable is added to the model in column 4 of Table V, the union coefficient drops slightly to .312, a 2 percent reduction. Each million dollars of business is associated with a 7.4 percent reduction in square feet built per hour, indicating once again the presence of diseconomies of scale in the industry. Since the union coefficient should rise if productivity falls with contractor size and union contractors are larger than nonunion contractors, it is unclear whether contractor volume is really a source of higher union productivity or is acting as a proxy for some other omitted variable. In fact, if it is a good proxy for overhead capital and labor, these results show that failure to control for them does not seriously contaminate the findings in Table III.

As one might expect from the cross tabulations in Table IV, the contractor responses to the questionnaire were not very helpful in econometrically identifying sources of higher union productivity. For instance since nonunion contractors were more likely to have labelled "supply of skilled workers" as a factor raising productivity (and less likely to label it as a factor lowering productivity), including two binary variables corresponding to those responses raises the union coefficient (S.E.) to .354 (.148). The one factor which does seem to be a possible source of higher union productivity is the use of standardized components. When one controls for whether the contractor felt that standardized components raised productivity, the union coefficient drops to .295, a fall of eight percent. This suggests that union contractors are more sensitive to labor requirements when selecting technologies, a result consistent with Mandelstamm's case study evidence. It also provides further evidence that union work rules are not as much of a barricade to contractor decision making as popular accounts would have one believe.

How much of the union productivity effect can be accounted for by these three sets of variables? When they are all included in the model in column 6 of Table V, the union coefficient falls to .237, a 26 percent reduction. The most likely factors which remain unidentified include, first of all, the type of training received by union and nonunion workers. No information was available about the sources of training for each crew. If the percentage of workers who have participated or graduated from apprenticeship programs were reported in future research efforts, the role of this factor could be identified. It would also be useful to have information about worker experience. Another factor which is probably at work is greater use of materials and technologies that economize on labor. The use of standardized components represents only one dimension of this decision. Finally, despite the negative results obtained for the questionnaire responses regarding the supply of skilled labor, it would probably be fruitful to collect information about how workers are actually recruited and selected in any future surveys.

Empirical Results: Elementary and Secondary Schools

A broader range of productivity measures is available for examination in the school sample. In addition to value added and square feet, output can be defined in two additional ways: number of classrooms and student capacity. It would be arbitrary to label any one of these as the ideal measure. For instance, depending upon how the schools were designed, structure A with more square feet of space than structure B could also have fewer classrooms or a lower student capacity. If the same number of labor hours were required to build each, productivity would be higher in structure A using the square footage measure but lower using classrooms built per hour or student capacity built per hour. Since the results may be very sensitive to the choice of the dependent variable, all of these possible measures are examined below.

All but one of the nonunion buildings are located in the South, making some of the difference in the union and nonunion means in Table VI attributable to locational factors. When productivity is measured in physical units, it is higher in the nonunion sample in spite of a higher capital labor ratio and a higher predicted wage for union projects. With respect to classroom square feet, student capacity and classrooms per hour, there is a sizable nonunion productivity advantage--at least 16 percent higher. Nonunion productivity is also 6 percent higher when productivity is measured in terms of total square feet per hour (including nonclassroom space). Except for the classrooms per hour figure, however, none of these differences is statistically significant. In contrast, the value added per hour measure indicates a union productivity advantage that is roughly comparable to that observed for the same measure over the office building sample. Even though it is distorted by higher union wages, keep in mind that differences in building characteristics could also distort the physical unit measures.

Table VI. Descriptive statistics for elementary and secondary school construction, by union status

Variable	Sample mean (N=68)	Union mean (N=57)	Nonunion mean (N=11)	T-test of equal means
Value added per hour	13.3 (3.4)	14.1 (3.0)	9.1 (1.6)	8.10***
Deflated value added per hour	16.0 (3.4)	16.7 (3.1)	12.0 (2.2)	4.83***
Square feet per hour	1.094 (.332)	1.082 (.317)	1.151 (.415)	0.62
Classroom square feet per hour	.577 (.283)	.562 (.295)	.657 (.206)	1.02
Student capacity per 1000 hours	12.5 (5.7)	12.2 (5.6)	14.2 (6.1)	1.08
Classrooms per 10,000 hours	4.9 (2.4)	4.7 (2.2)	6.0 (3.0)	1.65*
Capital expenditures per hour	.498 (.271)	.522 (.252)	.372 (.340)	1.70*
Hours of capital per hour	.161 (.121)	.162 (.100)	.153 (.203)	0.14
Labor quality index	7418 (364)	7489 (312)	7049 (401)	4.08***

Note: Standard deviations appear in parentheses below each mean.

* = significant at 90% confidence level.
** = significant at 95% confidence level.
*** = significant at 99% confidence level.

Production functions using five different productivity measures with and without building characteristics are reported in Table VII. The results show productivity is at least as high in the union sector as in the nonunion sector. In the value added specifications without building characteristics union productivity is 11.4 percent higher, but the null hypothesis can only be rejected at the 15 percent confidence level. When building characteristics are added to this specification, union productivity is 19.6 percent higher.

This estimate is suspiciously close to the union wage effect over this sample. If value added were deflated by a cross section price index, the results could be substantially altered. To test this possibility, the Dodge cost indexes reported in Allen were used as deflators in the results in columns 3 and 4. Since individual states are not identified in the Labor and Material Requirements data (to protect contractor confidentiality), a separate deflator was calculated for each of the nine Census subregions. This deflation has little impact on any of the coefficients. This is surprising because one would have at least expected the South dummy to increase substantially as a result of this adjustment. It is thus hard to say whether the deflated results "verify" the undeflated results or whether they indicate that the deflator does not accurately reflect price variation across this sample.

The results for the physical unit productivity measures are even more difficult to interpret. Not only is there no union-nonunion productivity difference in these specifications, but also productivity does not seem to vary with capital intensity. This was also the case in a variety of other specifications such as estimation of separate α and β for union and nonunion projects, omission of various independent variables, inclusion of additional independent

Table VII. Production estimates, elementary and secondary schools

Column: Output measure:	1 Value added	2 Value added	3 Value added/ Dodge index	4 Value added/ Dodge index	5 Square feet	6 Square feet	7 Total classrooms	8 Total classrooms	9 Student capacity	10 Student capacity
Constant	-5.896 (5.076)	-5.032 (4.959)	-5.380 (5.160)	-4.555 (4.978)	.941 (7.703)	4.227 (7.812)	-10.857 (10.659)	-10.744 (11.075)	7.567 (10.065)	2.235 (9.831)
log (K/L)	.082 (.037)	.058 (.038)	.082 (.038)	.058 (.038)	.015 (.056)	-.006 (.059)	-.067 (.078)	-.178 (.084)	.101 (.073)	-.036 (.075)
log (L)	-.011 (.027)	-.021 (.036)	-.008 (.027)	-.020 (.036)	-.132 (.040)	-.131 (.057)	-.429 (.056)	-.271 (.081)	-.417 (.053)	-.200 (.072)
Union	.108 (.075)	.179 (.076)	.111 (.076)	.181 (.077)	.041 (.114)	.008 (.121)	-.154 (.157)	-.001 (.171)	-.111 (.148)	.066 (.152)
Labor quality index	.975 (.567)	.899 (.550)	.940 (.576)	.871 (.552)	.054 (.860)	-.283 (.866)	.912 (1.190)	.692 (1.228)	-.815 (1.123)	-.518 (1.090)
North Central	-.150 (.062)	-.150 (.057)	-.152 (.063)	-.154 (.057)	.174 (.094)	.162 (.090)	-.179 (.130)	-.117 (.127)	-.018 (.122)	.041 (.113)
South	-.358 (.067)	-.302 (.066)	-.360 (.068)	-.303 (.066)	.151 (.102)	.104 (.103)	-.096 (.141)	-.024 (.147)	-.002 (.134)	.109 (.130)
West	-.147 (.068)	-.103 (.066)	-.185 (.069)	-.135 (.066)	-.003 (.103)	.002 (.104)	-.186 (.143)	-.232 (.148)	-.036 (.135)	-.031 (.131)
SMSA	.057 (.051)	.055 (.048)	.048 (.051)	.046 (.049)	-.034 (.077)	-.016 (.076)	-.080 (.106)	-.137 (.108)	.076 (.100)	-.003 (.096)
Elementary school		.006 (.053)		.007 (.053)		-.040 (.083)		.239 (.118)		.379 (.104)
Concrete frame		-.186 (.068)		-.190 (.068)		.064 (.107)		-.180 (.151)		-.242 (.134)
Masonry frame		-.134 (.057)		-.133 (.057)		-.021 (.090)		-.183 (.127)		-.131 (.113)

Table VII (continued)

Column: Output measure:	1 Value added	2 Value added	3 Value added/ Dodge index	4 Value added/ Dodge index	5 Square feet	6 Square feet	7 Total classrooms	8 Total classrooms	9 Student capacity	10 Student capacity
Wood frame		-.135 (.073)		-.154 (.073)		-.180 (.115)		.016 (.162)		-.113 (.144)
Masonry exterior wall		-.094 (.075)		-.100 (.075)		-.325 (.118)		-.364 (.167)		-.330 (.148)
Other exterior wall		-.100 (.098)		-.100 (.098)		-.333 (.155)		-.382 (.219)		-.398 (.195)
Prefabricated building units		.074 (.051)		.077 (.051)		.085 (.081)		.070 (.114)		.068 (.102)
One story		-.083 (.046)		-.086 (.046)		.069 (.073)		.154 (.104)		.201 (.092)
σ	.163	.147	.166	.147	.247	.231	.342	.328	.323	.291
R^2	.665	.765	.654	.763	.293	.466	.580	.666	.570	.699
F	14.62	10.36	13.91	10.26	3.06	2.78	10.17	6.37	9.79	7.39

Note: Standard errors are reported in parentheses below each coefficient. The mean (S.D.) of the dependent variable in columns 1 and 2 is 2.552 (.264); in columns 3 and 4, 2.771 (.264); in columns 5 and 6, .050 (.276); in columns 7 and 8, -7.737 (.495), and in columns 9 and 10, -4.482 (.462).

variables, and restriction of the sample to either elementary or Southern schools. The scale coefficient is the only parameter which is consistently estimated with precision. While the estimates indicate that diseconomies of scale are present in school construction, the β estimates in the student capacity and total classroom specifications are so much larger than that in the square feet specification that they are difficult to take seriously. Furthermore, the absence of acceptable estimates of α may also be contaminating the β estimates.

When output is measured in physical units, the model systematically overestimates (underestimates) the dependent variable in buildings with low (high) productivity, suggesting misspecification. Since the data set is fairly small, it was possible to examine it closely to determine possible sources of bias. One likely candidate is measurement error in the capital variable. Unlike the office building sample, interest expenses are not reported for schools. When the data are sorted by square feet per hour, there are implausible values of K/L in all ranges of the distribution. Further support for this view was obtained by dropping the projects with the 13 most extreme values of K/L from the sample. This raised the α coefficient (S.E.) to .131 (.105) in the square feet specification. The other coefficients remained relatively unchanged.

Since the regression results are so inconclusive, correlation coefficients for the key dependent and independent variables are reported in Table VIII. The interrelations among the dependent variables can be examined in the first five lines. While the physical unit productivity measures are highly correlated with each other, they tend to be uncorrelated with the two value added measures. The only noticeable correlation between these two sets of variables is that between the deflated value added and the square feet variables (.175), which is statistically

Table VIII. Correlation coefficients, elementary and secondary schools

	Value added per manhour	(Value added/ Dodge index) per manhour	Square feet per manhour	Student capacity per manhour	Total classrooms per manhour	Capital expenditures per manhour	Manhours	Predicted wage	Union
Value added per manhour	1.0								
(Value added/ Dodge index) per manhour	.974***	1.0							
Square feet per manhour	.103	.175	1.0						
Student capacity per manhour	-.002	.040	.588***	1.0					
Total classrooms per manhour	-.00007	.022	.593***	.896***	1.0				
Capital expenditures per manhour	.367***	.374***	-.006	.038	-.145	1.0			
Manhours	.114	.113	-.448***	-.734***	-.733***	.062	1.0		
Predicted wage	.550***	.461***	-.010	-.133	-.029	.094	-.052	1.0	
Union	.605***	.553***	-.068	-.129	-.191	.406***	.251**	.458***	1.0

Note: All variables except union status are in logarithmic form.

* = significant at 90% confidence level.
** = significant at 95% confidence level.
*** = significant at 99% confidence level.

significant from zero at the 85 percent confidence level. The interrelations between the dependent variables and the independent variables and those among the independent variables are reported in the bottom four lines. The independent variables are all highly correlated with the value added productivity measures, but are mostly uncorrelated with the physical unit productivity measures. This suggests that either there is severe measurement error in some of the independent variables or there are differences in building amenities which make physical output measures misleading.

In summary, no clear picture of the effect of unions on productivity emerges from the school sample. Simple union-nonunion comparisons of mean productivity in terms of physical output indicate no difference. The regressions and correlation coefficients indicate the same thing. The value added per manhour production function results point to higher productivity in the union sample. Despite probable bias in the union coefficient, this is the only specification where reasonable estimates of α and the labor quality coefficient were obtained. It is entirely possible that the union coefficient is more biased (in directions unknown) in the physical output specifications.

Conclusion

Samples of two different types of buildings have been examined in this paper in an attempt to measure the impact of unionism on productivity in the construction industry. The commercial office building results strongly support the conclusion of my earlier paper of higher productivity in the union sector. Square footage per manhour is 38 percent higher in buildings built predominantly by union labor. This estimate is quite a bit larger than the 17 to 22 percent difference that I obtained over the deflated Census of Construction Industries sample.

The sources of this difference are only partially identified. Lower supervisor to production worker ratios and greater use of technologies and materials that economize on labor hours seem to be part of the story. Unobserved labor quality, economies of recruiting and screening, managerial inputs, and training are no doubt also important but their impact could not be quantified here. It would be useful in future work to design an experiment combining the detailed hours, equipment, and materials data which BLS collects with questionnaire data similar to that collected by Bourdon and Levitt. While the results reported here should eliminate any doubts that at least in some institutional settings productivity can be significantly higher under unionism, the mechanisms through which this happens have not been fully identified.

The union productivity effect estimates over the school sample range between 20 percent in the value added specification to zero in the physical output specifications. Why are the latter results so different across the two samples? One possible explanation is that schools are so heterogeneous that output cannot be represented in a single measure. In addition to classroom space, schools contain such features as gymnasiums, auditoriums, swimming pools, and laboratories. To explore this possibility, the ratio of classroom to total square feet was added to the model. The estimates of α, β, and b changed very little in any of the specifications. Addition of square footage to student capacity ratios to the model also shed no new light on the results. While these probes of the data are admittedly crude, they nonetheless suggest that heterogeneity may not be a severe source of bias. Another reason for discounting this explanation is the fairly well behaved nature of the office building results. Reasonable estimates were obtained over that sample even though the structures ranged in size from 3,000 to 1.7 million square feet. Is the school sample more heterogeneous than that?

Another explanation is that the owners of elementary and secondary schools do not have the same incentives as the owners of commercial office buildings, which may prevent resources from being allocated efficiently. The demand elasticity for structures is likely to be lower for state and local governments than for the private sector. Government officials are given a budget by a legislative body which sets an upper limit for the cost of the building. Contract officers have little incentive to obtain bids below that amount. They cannot spend any money that they save on other projects; they cannot receive any personal reward. In areas where elected officials are heavily indebted to unions or contractor associations, attempts on the part of government employees to minimize costs may even be actively discouraged.

Even if government officials had the incentive to produce buildings at minimum cost, they usually lack the means. Collusion is always possible in sealed bid auctions. Private sector owners have several devices at their disposal to prevent this, including delay or cancellation of the project, relocation of the project, and negotiation with individual bidders for further cost reductions before signing the contract. None of these options is usually available in the public sector. As a result, contractors and unions stand to collect rents in public construction.

The mere existence of rents of course does not imply inefficient factor allocation. In fact one would expect nonunion contractors to appropriate all rents for themselves by minimizing costs. This is much less likely in the union sector. But even if unions have the bargaining power to share the rents, how are they distributed? Agreements which raise wages on public construction projects above those in the private sector would signal to the entire community (especially potential opponents of those in office) that rents are present, so this is not a stable solution. However, if rents are distributed in the form of such commodities as increased on the job leisure or job opportunities for the least skilled union members, the data are not likely to trace out a production function reflecting cost minimizing behavior.

Some support for this explanation can be obtained by comparing our commercial office building sample with a sample of federal office buildings built in about the same time period. Cost per square foot is greater in the federal sample ($41.28) than in the commercial sample ($22.36). Labor's share of output is also higher in the federal sample. Onsite wages represent, on average, 34.0 percent of the contract amount in the federal sample; 26.7 percent in the commercial sample.[22] Similar results emerge when the comparison is between public and private housing. Cost per square foot in a sample of 1968 public multifamily projects was $15.22, with onsite labor accounting for 32.4 percent of total cost. In a sample of private multifamily projects built three years later, cost per square foot was $12.96 and labor's share was 28.0 percent.[23] While this evidence is far from conclusive in and of itself, further work investigating this hypothesis is clearly warranted.

It has also been suggested that the behavior of union workers on the job is sensitive to the demand for their services. Since the construction industry was heading into a recession at the time of the office building survey, it is possible that a study during another period would yield different results.

Even in cases where productivity is higher in the union sector, the "bottom line" issue is whether this is more than offset by the higher wages union contractors have to pay.[24] The union wage effect estimate for office buildings reported above falls well within the range of the union productivity effect point estimates. This indicates not only is unionization correlated with higher productivity in that sector, but also the returns from that productivity have been shared by capital and labor, exactly the same result obtained by Mandelstamm for residential construction in Ann Arbor and Bay City, Michigan in 1957. The school results suggest this will not always be the case. Further research over other types of buildings and in different time periods will be needed to establish the overall effect of the building trades unions on efficiency.

Footnotes

[1]References to most of the studies examining the effect of unions on productivity are reported in Richard B. Freeman and James L. Medoff, "The Two Faces of Unionism," The Public Interest, No. 57 (Fall 1979), p. 80. More recent studies include Steven G. Allen, "Unionized Construction Workers Are More Productive," Quarterly Journal of Economics, forthcoming and Kim B. Clark, "Unionization and Firm Performance: The Impact of Profits, Growth, and Productivity," Working Paper No. 990 (Cambridge, Mass.: National Bureau of Economic Research, September 1982).

[2]John T. Addison, "Are Unions Good for Productivity?" Journal of Labor Research, Vol. 3, No. 2 (Spring 1982), pp. 125-138.

[3]The use of value added as a measure of output will produce upward bias in the union coefficient in a production function when both of the following conditions hold: (1) higher union wages are passed on to customers in the form of higher prices (for instance, in markets where there is no nonunion competition) and (2) product demand is inelastic.

[4]Major studies reporting union-nonunion differences in training, occupational structure, work rules, hiring procedures, and other work practices in construction include William Haber and Harold M. Levinson, Labor Relations and Productivity in the Building Trades (Ann Arbor, Mich.: University of Michigan, 1956); Allan B. Mandelstamm, "The Effects of Unions on Efficiency in the Residential Construction Industry: A Case Study," Industrial and Labor Relations Review, Vol. 18, No. 4 (July 1965), pp. 503-521; Herbert R. Northrup and Howard G. Foster, Open Shop Construction (Philadelphia, Pa.: University of Pennsylvania Press, 1975); and Clinton C. Bourdon and Raymond E. Levitt, Union and Open-Shop Construction (Lexington, Mass.: D. C. Heath and Co., 1980).

[5]Productivity measurement problems in the construction industry are discussed in U. S. National Center for Productivity and Quality of Working Life, Measuring Productivity in the Construction Industry (Washington, D. C.: G.P.O., undated).

[6]Complete references are reported in Allen, "Unionized Construction Workers."

[7]Steven G. Allen, "How Much Does Absenteeism Cost?" Journal of Human Resources, Summer 1983.

[8]In the May 1973-75 CPS the union wage effect estimate increases from 54 to 66 percent when age and schooling are dropped from the model.

[9]The Cobb-Douglas specification imposes three important restrictions: (1) the elasticity of substitution between labor and capital equals one; (2) homotheticity (i.e., all isoquants along a ray from the origin have the same slope); and (3) homogeneity (i.e., the elasticity of cost with respect to output is constant). Unless these factors are correlated with unionization, the estimates of the union intercept in the Cobb-Douglas specification will be unbiased. These restrictions are removed in another paper, in preparation, which examines union-nonunion differences in the cost of building office buildings and schools.

[10]This specification was selected because the distribution of observations by percent union is highly clustered near zero and one, as shown below:

Percent Union	Schools	Office Buildings
0-9	8	10
10-19	1	5
20-29	0	3
30-39	1	0
40-49	1	1
50-59	4	1
60-69	2	1
70-79	1	5
80-89	0	5
90-99	31	34
100	19	18

Replacement of U_i by the continuous percent union variable has virtually no effect on the coefficients, but does increase standard errors.

[11]More details about each survey are reported in U. S. Department of Labor, Bureau of Labor Statistics, Labor and Material Requirements for Commercial and Office Building Construction, Bulletin 2102 (Washington, D. C.: G.P.O., 1982) and U. S. Department of Labor, Bureau of Labor Statistics, Labor and Material Requirements for Elementary and Secondary School Construction, Publication No. BLS/LAB Constr-72/81 (Springfield, Va.: N.T.I.S., 1981).

[12]U. S. Bureau of the Census, Census of the Population: 1970 Subject Reports, Final Report PC(2)-7A, Occupational Characteristics (Washington, D. C., G.P.O., 1973), pp. 1-11.

[13]These size differences are equally apparent when one compares average square footage. The average for union office buildings is 208,815; nonunion, 27,319. The average for union schools is 98,108; nonunion, 85,250. To test whether this size difference biased the results, (3) was estimated over samples where the union buildings which were larger than the largest nonunion building were excluded. The union coefficients were not sensitive to this restriction, so these results are not reported below.

[14]Dodge Building Cost Services, 1977 Dodge Construction Systems Costs (New York, N. Y.: McGraw-Hill, 1976), pp. 221-247. Two qualifications on the use of these data should be noted. First, the BLS does not distinguish between precast and poured concrete in the surveys. Onsite productivity is considerably greater when the former is used. Second, the specific type of wood, steel concrete, brick, and the like used in the building is not reported. There is often considerable variation in unit labor costs within, say, all buildings with masonry exterior walls ($1.47 to $6.68 per square foot). This range often overlaps with that of other materials. For instance, cost per square foot of

various wood exterior wall systems ranges between 59 cents to $1.57 per square foot. Both of these factors introduce error into all predictions made about building characteristic coefficients with the Dodge data.

[15]Ibid., pp. 69-112.

[16]Ibid., pp. 113-133.

[17]Charles Brown and James Medoff, "Trade Unions in the Production Process," Journal of Political Economy, Vol. 86, No. 3 (June 1978), pp. 371-372 and Allen, "Unionized Construction Workers."

[18]Dodge Building Cost Services, op. cit., pp. 221-247.

[19]Ibid., pp. 189-210.

[20]In a specification not reported in Table III, the labor quality variable was used to "deflate" L_i for each project by restricting the O_i coefficient to one. Since this had no effect on the estimates of α, β, and b, these results are not reported in Table III.

[21]Survey of Current Business, July 1977, p. 43; U. S. Bureau of the Census, 1977 Census of Construction Industries, Geographic Area Series CC77-A-10, U. S. Summary (Washington, D. C., G.P.O., 1980), p. 9.

[22]U. S. Department of Labor, BLS Bulletin 2102.

[23]Robert Ball, "Labor and Material Requirements for Apartment Construction," Monthly Labor Review, Vol. 98, No. 1 (January 1975), pp. 70-73; Robert J. Prier, "Labor Requirements Decline for Public Housing Construction," Monthly Labor Review, Vol. 103, No. 12 (December 1980), pp. 40-44.

[24]The cost of building with union as opposed to nonunion labor is estimated with a translog cost system in another paper, in preparation.