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UNIONIZATION, MANAGEMENT ADJUSTMENT AND PRODUCTIVITY

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Summary

Unionization, Management Adjustment and Productivity

The effect of unionization on productivity is examined in this paper using time-series data on selected establishments in the U.S. cement industry. The analysis combines statistical estimation of the union impact and interviews with union and management officials to forge a link between econometric estimation and the traditional institutional analysis of union policy and management adjustment. The econometric analysis primarily deals with the problem of identifying the impact of the union in the face of firm specific effects and adjustments in labor quality. The case studies are designed to shed light on the question of how unionization affects productivity. The empirical results support the conclusion that unionization leads to productive changes in the operation of the enterprise. Evidence from the case studies suggests that much of the gain in productivity derives from a series of extensive changes in management personnel and procedure. These adjustments are a management response to changes in the employment contract which follow unionization.

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Unionization entails fundamental changes in the nature of the employment relationship. In a non-union setting the rules governing the workplace are largely determined by management, with worker influence limited to exit from the firm if the implied labor contract is not attractive. Collective bargaining establishes a more direct means of influence through the processes of contract negotiation and administration. These procedures involve workers and the union in setting the terms and conditions of employment, and in day to day operations. The literature on collective bargaining is replete with evidence that these procedural changes are accompanied by changes in the substance of the employment relation.[1] Recent analysis of cross section data on value added per hour worked suggests a positive union productivity effect.[2] Yet there is very little evidence about the change in productivity within an enterprise after collective bargaining is introduced. While numerous case studies have identified changes in the internal operation of the firm after unionization, there has been no attempt to link the institutional information with empirical analysis of the union's effect on productivity. Both kinds of information are essential to a full understanding of the impact of the union.

This paper examines the effect of the union on productivity using data from the U.S. cement industry. The analysis uses establishment level data together with interviews of management and union officials to forge a link between econometric estimation and the traditional institutional analysis of union policy and management adjustment. Particular focus in the empirical work is on the problem of identifying the effect of unionization on productivity in the face of firm specific effects, and adjustments in labor

quality. The case studies, and most of the econometric analysis, are based on the experience of six cement plants which changed union status in the 1953-1976 period. The statistical analysis is designed to provide an estimate of what impact unionization had, while the institutional analysis is intended to shed light on the question of how unionization influenced the operation of the enterprise. The paper is divided into four sections. The first section presents the basic framework used in the empirical analysis and includes a discussion of the empirical model, the characteristics of the industry and the data. Section II presents the econometric analysis of the union impact and section III contains evidence on changes in internal operations after unionization. Section IV presents implications and conclusions.

Section I: The Analytical Framework

The theoretical connection between unions and productivity has been discussed at length elsewhere and will only be summarized briefly here.[3] In the context of a representative production process in which output is a function of capital and labor inputs, the productivity of labor depends on the capital-labor ratio, the scale of operations and various institutional factors - e.g. methods of organization, effectiveness of management, and the motivation of workers. Traditional analysis limits the influence of the union on productivity to capital-labor substitution induced by the union wage effect.[4] While increasing the capital-labor ratio in response to a rise in the relative wage raises the productivity of labor, capital productivity declines and the net effects are increased costs and misallocated resources. A second channel of influence recognizes that unionization is

likely to affect methods of organization and other aspects of the internal operation of the firm. If unionization puts pressure on management to improve operations, for example, the production process may yield a larger volume of output for any combination of capital and labor.[5] Of course, the opposite conclusion holds if unionization reduces motivation or otherwise impedes the effective operation of the enterprise.

The effect of unionization on the organizational determinants of productivity depends on changes in the labor contract and on adjustments made by workers and management to new provisions. In most situations, unionization entails a shift in relative power and increased worker control over conditions of work. Freeman has argued that these changes reduce turnover by giving workers a "voice" in the operation of the enterprise.[6] A reduction in turnover has clear implications for firm specific training, the effectiveness of work groups, and productivity. Similarly, the use of seniority rules may improve training and morale. Where promotion depends on seniority, rivalry among workers may be reduced and incentives for assistance and cooperation increased.[7] In addition, seniority criteria may be less arbitrary than rankings based on managment's assessment of ability (or other subjective criteria). Workers' perception of their jobs may improve with consequent improvements in motivation and morale.[8]

The shift in power which accompanies unionization substantially alters the task of management. The implication of these changes for productivity is unclear. With higher wage rates and a formal grievance procedure, there is an incentive for management to increase the effort obtained from a given level of labor input, and to address aspects of the production process which may have been neglected.[9] The upshot is that management may

respond to unionization by taking steps to improve performance. Yet unionization may lead to reductions in productivity. Union power may be used to protect malfeasance and build reduced work effort into the contract. Management's ability to fire undesirable workers may be reduced and the union contract may advance rules which restrict management's ability to adjust to changing conditions. Instead of improving morale, seniority rules may force the promotion of less productive workers, and rules limiting displacement of workers may impede technological advance. Numerous petty issues may be raised through the grievance process, resulting in a disruption of production.

These brief comments suggest that the effect of unionization depends on a complex range of adjustments made by workers and management. Simply identifying a particular change in the labor contract is not sufficient to establish the impact of the union, or the process leading to changes in performance. The resolution of the issue not only requires more detailed information on organizational adjustments, but a statistical estimate of the union effect as well.

The Empirical Model

Empirical analysis of the union impact and associated institutional change poses several problems of identification. The basic difficulty lies in constructing an empirical "experiment" which isolates union/non-union differences in productivity due to changes in the internal operation of the enterprise. There are three principle problems. First, where union and non-union establishments compete in different markets, the effect of unionization on productivity may be difficult to separate from its effect on prices if output is not measured in physical units.[10] Moreover productivity

differences may arise from differences in technology if union and non-union establishments produce different products.[11] Second, establishments may differ in productivity because of inherent differences in the quality of management or other organizational factors which are difficult to measure and control for in statistical analysis. Unless controls for such "firm effects" are developed, the effect of the union on productivity cannot be identified without assuming that the fixed effects are independent of union status. Third, the union wage effect gives firms incentive to recover costs by substituting higher for lower quality workers. The implication is that the capital-labor ratio must be adjusted for labor quality differences in order to identify the union impact due to organization factors. It is well known, however, that measuring the quality of labor is inherently difficult.[12]

Each of these problems affects the measurement and identification of the union impact. Similar difficulties arise in attempting to identify how the process of unionization affects productivity in a particular establishment. In the first instance, simply finding out what changes in internal operations occurred following unionization is not trivial. Information sources may include company and union documents, but insight into the details of actual practice can only be developed through retrospective interviews. The process is thus observed through the perceptions and memory of participants. Furthermore, in the context of changes in operations over time, the presence of technological change common to all establishments complicates the process of inferring the role of unionization.

The design of the empirical analysis in this paper reflects each of the problems of identification. Case studies of six plants which change union status are used to examine changes in operations after collective bargaining is introduced. The problem of measuring the union impact is studied in the context of a relatively simple model of production. Output is assumed to be a function of the capital stock (K), the input of production workers (L), and supervisory personnel (S). In addition, organizational factors may influence the level of output obtained from a given combination of the three inputs. Principle focus in this paper is on the change in output within a given establishment over time. In a time series context, technological innovation is likely to lead to changes in the methods of organization and management which improve the efficiency of operations. Moreover, changes in the rate of capital utilization may be an important source of variation in capital input. Assuming that technology in the i^{th} firm is of the Cobb-Douglas form, these aspects of production may be written as:

$$Q_{it} = A_o e^{\delta t}[K_{it}^{\alpha_1} R_{it}^{\alpha_2} L_{it}^{\beta} S_{it}^{\gamma}] \qquad (1)$$

where R is the rate of utilization, and a simple exponential trend has been assumed for technological change.[13] In this framework output per manhour of production workers is given by

$$\ln(Q/L)_{it} = \ln A_o + \delta t + \alpha_1 \ln(K/L)_{it} + \alpha_2 \ln(R/L)_{it} + \gamma \ln(S/L)_{it} + (\theta - 1)\ln L_{it} \qquad (2)$$

where $\theta = \alpha_1 + \alpha_2 + \gamma + \beta$ is a measure of returns to scale. Equation (2) assumes different elasticities of output with respect to the stock of capital and the rate of utilization. This specification has found support in a variety of data sets and

will be examined here. The lack of employment data precludes extension of the specification to the labor inputs as well.

The traditional effect of unionization on input ratios is assumed to be captured in changes in the capital-labor ratio and the ratio of supervisory to direct production manhours. The effect of the union on organization factors can be summarized as $A_o^* = A_o\ (1 + b)$, where A_o^* can be thought as the index of organizational efficiency following unionization. In this formulation b is the productivity differential between the union and non-union regimes; given the theoretical considerations examined earlier, b may be either positive or negative. If we assume that unionization does not affect the technology of production, then the organization effect may be introduced into the empirical model by re-writing (2) as:

$$\ln(Q/L)_{it} = \ln A_o + \delta t + bU_{it} + \alpha_1 \ln(K/L)_{it} + \alpha_2 \ln(R/L)_{it} + \gamma \ln(S/L)_{it} + (\theta - 1)\ln L_{it} \qquad (3)$$

where U_{it} is a dummy variable which takes the value 1 if the firm's work force is unionized and zero otherwise.[14]

The Cement Industry Data

Estimation of the basic model is based on establishment data from the U.S. cement industry. The industry has a number of characteristics which influence the structure and interpretation of the analysis.[15] Cement is a fine gray powder derived from a highly capital intensive process in which limestone and clay (or shale) are crushed and ground, and fired to 2700°F in a large rotating kiln to form partly fused pellets called "clinker." The clinker is then finely ground, usually with a small amount of gypsum which controls setting time. The cement powder produced in this process has a very low value-to-weight ratio so that shipping costs generally preclude extensive geographic penetration by

a single establishment. The result is a highly regional market structure, with the bulk of output from a given establishment shipped within a 200 mile radius.[16]

The regional nature of the industry is reflected in the structure of collective bargaining, where single employer agreements with substantial local negotiations are the rule. The unionized sector is dominated by the United Cement Lime and Gypsum Workers International Union, who represent 75 percent of the plants in the industry.[17] A little over 8 percent are non-union, and the remainder are divided among the Steelworkers, joint councils and independent unions. In terms of employment and compensation the cement industry is much like other highly unionized, highly capital intensive sectors. Most tasks in a cement plant involve operating, monitoring or maintaining large peices of equipment so that skill levels range from semi-skilled operators to highly skilled machinists and electricians. Most employment is concentrated in plants with 150-200 workers and the employment relationship is relatively long term.[18] From 1958 to 1974 the monthly quit rate in cement averaged 0.648 percent compared to 1.910 percent for total manufacturing.[19] At least part of the reason for extended job tenure lies in the relatively high rates of compensation: in 1976, average hourly earnings in cement were $7.26 compared to $5.19 in manufacturing.[20]

Perhaps the most crucial aspect of the industry for the current analysis is the relatively homogeneous nature of the product. Cement is essentially a commodity produced to universally accepted ASTM specifications with very little variance from one plant to another.[21] The homogeneous nature of the product together with official product classifications and quality standards permits comparison of output in different establishments in physical terms. Since 1919 the Portland Cement Association has

conducted an annual survey of association members which provides information on the production of clinker, finished cement, cement shipments, and manhours for each of the respondent firm's establishments. This survey constitutes the basic source of data used in the empirical analysis.[22]

The PCA survey provides annual data on tons of finished cement, hours of work, plant location, annual plant capacity and, for recent years, the age and capacity of individual kilns. The data on manhours is broken down by department, permitting the construction of variables measuring production and supervisory or non-production labor input. The supervisor category includes plant management, foremen and supervisors, clerical staff and laboratory personnel. The production category includes workers in the quarry, the raw grinding and finishing departments, and the general labor group. Beginning in 1973 information is available on the installation date and "practical" capacity of individual kilns. Letting C_j be the capacity of kilns of the $_j$th vintage, the capital stock in the ith plant in year t is defined as

$$K_{it} = \Sigma\lambda^{t-j}C_{ijt} \qquad 0<\lambda<1 \tag{4}$$

The adjustment parameter λ reflects the effects of depreciation, obsolescence and vintage.[23] The data set is completed with information on utilization and union status. Utilization is measured as the ratio of cement production to unadjusted plant capacity. Union status was determined by examining records from the Cement Employers Association, and the United Cement, Lime and Gypsum Workers International Union.

Section II: Estimates of the Union Effect

The cement industry provides a useful empirical framework for the analysis of unionization and productivity. The use of data on establishments producing homogenous output measured in physical units avoids the problems inherent in comparing productivity in value terms. Moreover, among plants of the same vintage technology is relatively standardized, leaving little room for major differences

between union and non-union establishments. Evidence presented in Clark (1979) shows that constraining the production process in the union and non-union sectors to be identical does not obscure important technological distinctions and does not affect inferences about the union effect. The evidence from cross section data suggests the union productivity differential is about 6-8 percent irrespective of the technology constraint. These results imply that price and technology effects are controlled for in the choice of industry. Thus, primary focus in the empirical work here is on the analysis of firm fixed effects and labor quality using time series data on six establishments which change union status.

Unionization and Firm Specific Effects

The model specified in (3) assumes that the parameters of the production function are constant across firms and over time. Even with a common set of output elasticities, however, productivity may vary across establishments because of differences in organizational factors. It is common in production function analysis, for example, to attribute part of any unexplained variation in output to differences in managerial ability.[24] Differences in morale and motivation may play a similar role. If differences in managerial ability and motivation exist, omitting them may lead to biased estimates of production parameters, including the union productivity effect. Without direct measures of the organizational factors, productivity effects specific to the firm cannot be held fixed in cross section data. With the addition of a time series dimension, however, firm specific effects can be introduced through assumptions about the error term. In the present instance, we assume that the errors in (3) have the following "fixed effects" structure:

$$v_{it} = \mu_i + \varepsilon_{it}$$

$$Ev_{it} = \mu_i \qquad (5)$$

$$\text{cov}(v_{it}, v_{is}) = E\varepsilon_{it}\varepsilon_{is} = \begin{cases} \sigma_v^2 \text{ when } i = j \text{ and } t = s \\ 0 \text{ otherwise} \end{cases}$$

We have assumed that the firm specific component (μ_i) is fixed, and that ε_{it} are uncorrelated across establishments and over time.[25] Under this specification, consistent estimates of (3) can be obtained with pooled data by introducing individual establishment intercepts.

The introduction of firm intercepts controls for a particular kind of auto-correlation in the errors of a given establishment. Without separate intercepts, the errors of a given firm will appear to be serially correlated because the mean error (μ_i) is common to all observations. Even with the common mean removed, however, it is entirely possible that additional serial correlation will remain. To allow for that possibility, (3) may be estimated assuming a first order autoregressive process:

$$\varepsilon_{it} = \rho\varepsilon_{it-1} + u_{it} \qquad (6)$$

where ρ is the autocorrelation coefficient and u_{it} has mean zero and is uncorrelated across establishments and over time. Under this assumption consistent estimates of (3) can be obtained by covariance analysis with a non-linear procedure to estimate ρ.

Estimation of the basic model and its several variants is based on data for six establishments which underwent unionization in the 1953-1976 period.[26] Since some of the plants were constructed after 1953 we do not have data on all establishments for each year. There are a total of 104 observations or an average of 17.3 per establishment. In order to provide perspective Table 1 presents summary measures of productivity and its determinants for the industry as a whole and for the before/after sample. The before/after sample is further examined in line 2 of the table which presents mean values from the union and non-union regimes.[27] The data in line 1 clearly indicate that most of the plants in the before/after sample are

Table 1

Productivity and Its Determinants in the Before/After Sample

Category	Average Productivity (A/L)	Utilization (R/L)	Capital-Labor Ratio (K/L)	Supervisor Labor Ratio (S/L)	Total Production Manhours (L)	Total Capacity (C)	Kiln Age
1. Industry Comparison over the period 1973-76.							
a) industry total	2.16 (.82)	-	2.24 (2.20)	.31 (.13)	321.43 (150.84)	566.92 (330.83)	21.09 (13.01)
b) before/after sample	2.78 (.82)	-	2.98 (.59)	.33 (.17)	163.18 (57.84)	531.83 (151.83)	14.10 (4.13)
2. Comparison of the Union/Non-Union Regimes							
a) non-union means	2.24 (.53)	.0056 (.0020)	3.17 (2.58)	.31 (.15)	152.93 (55.04)	455.42 (165.65)	-
b) union means	2.74 (.73)	.0065 (.0040)	3.07 (.73)	.31 (.19)	152.84 (58.05)	493.73 (146.12)	-

Note: average productivity and the capital-labor ratio are measured in tons per manhour, while total capacity is in tons.

considerably younger than the industry average. The age of the plants is reflected in the capital-labor ratio and the level of productivity. On average the before/after plants are 25 percent more productive than the industry average, and operate with a 28.7 percent higher capital-labor ratio. It should be noted that the average level of productivity in the sample masks a good deal of diversity across plants. The diversity appears to be more than might be explained by variation in input ratios, suggesting the presence of firm specific effects. The data on total capacity suggest that the before/after plants are slightly smaller than the industry average, but are much more tightly grouped around the mean.

The differences in average productivity and input ratios following unionization are presented in line 2. The data reveal a substantial increase in productivity in the union regime, while the capital-labor ratio actually falls. The fall in the capital-labor ratio reflects the adjustment procedure which reduces K as time passes, unless new capacity is added. In general, changes in input ratios are quite small and the evidence suggests that the sign and magnitude of the union differential will depend more heavily on the effect of utilization rates, returns to scale and technology changes than on variation in input ratios.

Section II: Empirical Results

Table (2) presents estimates of the basic model under several alternative specifications. Without parameter restrictions, a full version of equation (3) cannot be estimated with the cement industry data. The rate of utilization is measured as the ratio of output to unadjusted capacity, which also serves as the basis for our measure of the capital stock. Thus under the complete specification, equation 3 is almost an identity. In the absence of independent information about utilization (or the capital stock) restrictions on the parameters are necessary to estimate the

union effect. One possibility is to adopt the specification that R is constant or proportional to variations in the stock. A second possibility is to impose constant returns to scale. This assumption is consistent with evidence from cross section data reported in Clark (1979). Estimates under both assumptions are presented in table 2.

The empirical evidence suggests that unionization increases productivity after controlling for capital-labor substitution, technological change and individual firm effects. In line 1 utilization is assumed to be proportional to the capital stock and is omitted from the equation. Before correcting for autocorrelation the point estimate of the union effect lies between 8 and 10 percent with the higher estimate coming under non-constant returns to scale. Except for the estimated scale parameter in line 1a, the production parameters are consistent with evidence from the cross section data. Given the dominance of the time series dimension of the data, total man-hours may be picking up variation in the omitted utilization variable. The apparent bias in the scale coefficient, however, is of little consequence for estimation of the union effect.

The unadjusted Durbin-Watson statistics in lines 1a and 1b provide some indication of the extent of serial correlation. The effects of autocorrelation are examined assuming a first order autoregressive process in the errors. We retain the fixed effects specification of the establishment component in the error, and constrain the autocorrelation coefficient to be identical in each firm. We further estimate the union effect conditional on values of the production parameters obtained in cross section data. Initial unconstrained estimates yielded absurd values of the output elasticities and returns to scale.[28] Fixing the production parameters transforms the model into an equation explaining total factor productivity. In effect we regard the time series evidence on the production parameters as relatively weak, and have allowed the results from the cross section analysis to serve as dominant prior information.

The autocorrelation correction has little effect on the estimated union coef-

Table 2

Estimates of the Union Effect in the Before/After Sample

Model Specification	Cons	ln(R/L)	ln(K/L)	ln(S/L)	lnL	Time	Region	Union	Firm Dummies	R^2	SEE	D.W.	ρ
1. Capacity utilization proportional to variations in the capital stock													
a) non-constant returns	-17.14 (10.60)	-	.322 (.109)	.075 (.102)	-.235 (.132)	.010 (.005)	-	.107 (.064)	X	.522	.179	.89	-
corrected for autocorrelation	3.260 (17.262)	-	[.45]	[.12]	[-.05]	-.001 (.009)	-	.104 (.070)	X	.456	.147		.576 (.091)
b) constant returns	-17.14 (10.70)	-	.410 (.098)	.156 (.093)	-	.009 (.005)	-	.084 (.063)	X	.505	.181	.83	
corrected for autocorrelation	3.311 (17.72)	-	[.45]	[.12]	-	-.001 (.009)	-	.103 (.070)	X	.467	.147		.590 (.091)
2. Capacity utilization allowed to vary under constant returns to scale - parameters constrained to cross section values	-12.28 (6.54)	[.45]	[.45]	[.12]	-	.008 (.003)	-	.100 (.040)	X	.764	.113	.82	
corrected for autocorrelation	-1.610 (20.00)	[.45]	[.45]	[.12]	-	.002 (.005)	-	.064 (.040)	X	.856	.084		.583 (.081)
3. Estimates controlling for omitted variables													
a) non-constant returns	1.072 (.563)	-	.244 (.100)	.073 (.093)	-.175 (.122)	-	.473 (.107)	.092 (.046)	X	.593	.165	.81	-
b) constant returns	.293 (.154)	-	.306 (.093)	.131 (.084)	-	-	.486 (.107)	.069 (.043)	X	.584	.166	.79	-
c) constant returns with utilization	2.345 (.054)	[.45]	[.45]	[.12]		-	.219 (.066)	.121 (.029)	X	.777	.110	.77	-

Note: [ ] indicates a fixed parameter taken from cross section estimates reported in Clark (1979)

ficient in the basic model given in line 1. Under constant returns the estimated coefficient actually increases, while the standard error rises slightly. Minor changes are registered in the non-constant returns results. The insensitivity of the results to the autocorrelation specification is not due to fixing the production parameters. When the constrained version of line 1a was estimated without correcting for autocorrelation, the union coefficient was .108 with a standard error of .070.

Autocorrelation is a more important factor in line 2 where the utilization rate is introduced under the assumption of constant returns to scale. Without correcting for autocorrelation, the estimated union effect is little changed from the estimates in line 1. Under the autocorrelation specification the estimated union effect declines to .064. Thus, allowing for autocorrelation makes the union effect more sensitive to model specification and reduces somewhat the precision of estimates. In general, however, the evidence suggests that unionization led to an increase in productivity, with the magnitude of the effect likely to fall in the range from 5-10 percent.

The estimates of the union effect take into account short run variations in input ratios, scale, and establishment effects; trend movements in basic variables, as well as technological change, are captured in the time trend. In spite of these controls, the possibility that the union coefficient reflects unmeasured changes in the environment cannot be ignored. It is not impossible to conceive of abrupt changes in the environment of the firm which are coincident with unionization, imperfectly reflected in input ratios and a smooth time trend, and which raise productivity. The impact on productivity of any omitted variables with the same time structure as the union variable will be compounded in the union coefficient.[29]

The seriousness of the omitted variable bias is not obvious. Since the plants in the before/after sample were organized at different points in time, the omitted variable argument requires that abrupt changes in the environment occur at different times, and perhaps in different regions. It seems unlikely that such changes would happen to coincide with unionization in each instance. Nevertheless, the issue may be examined using data on a control group which does not undergo unionization, but is subject to other changes in the environment. As long as productivity in the control group reflects the influence of omitted variables, comparison with the before/after plants should give at least a rough indication of their effects. For each before/after plant we use a control group composed of the establishments in the region where the plant is located. The use of a regional control is consistent with the regional structure of the industry, but should also capture any changes in the environment common to all firms.[30]

It is not appropriate simply to introduce average regional productivity as a control variable in the basic regression without some adjustments. Productivity in the region presumably reflects trend movements in technology, as well as the more discontinuous changes which are of principle interest here. Accordingly, we drop the time trend from the basic model and allow regional productivity to capture both gradual and uneven changes in the firm's environment. The results presented in line 3 suggest that the previous finding of a union effect on the order of 5-10 percent is essentially unchanged after controlling for variation in regional productivity. With utilization excluded, the union effect under non-constant returns is .092 with a standard error of .046; under constant returns the union coefficient is .069 with a standard error of .043. In contrast, adding the utilization rate assuming constant returns to scale increases the union effect to .121 with a standard error of .029. There is little evidence of systematic bias in the estimated union productivity effect due to omitted factors correlated with productivity in other establishments in the region. The region correction leaves basic conclusions unchanged.

Taken together, the empirical evidence in this section suggests that unionization led to increases in productivity. The direction of the union effect appears to be quite robust, while the exact order of magnitude and precision of the estimates depends on model specification. However, the variation in the size of the effect occurs over a moderately narrow range, and in general the evidence is consistent with a union productivity differential of about 7-8 percent.

Unionization and Labor Quality

This section uses evidence obtained in case studies of unionization in the six plants together with theoretical analysis, to gauge the extent of quality bias in the empirical anlaysis in section II. The estimates in table 2 fail to control for differences in worker quality following unionization. If unionization induces firms to hire higher quality workers, the estimated union effect may reflect quality differences as well as any organizational changes in the enterprise. The evidence examined in this section does not address the issue of union/non-union differences in worker quality. The more modest purpose of the analysis is to place an upper bound on the potential bias, under the assumption that unionization leads to an increase in the quality of labor.

The effect of unionization on labor quality depends on the extent of change in the level and the structure of wages, and the technology of production. To fix ideas, consider a cement plant prior to unionization which operates in a competitive labor market comprised of low and high quality workers. Prior to unionization the firm presumably has complete freedom to match workers and jobs, so that a quality mix is chosen which minimizes cost, given technology and the structure of wages defined in terms of quality. Unionization is likely to encourage a shift in the quality mix. If, for example, the union contract restricts hiring to an entry job classification with a common starting wage and establishes promotion based on seniority, the firm has a clear incentive to substitute high for low quality workers.

As long as the present value of the earnings stream of high quality workers rises, unionization will be followed by an increase in the average quality of the work force.

The extent of the quality increase and the resultant rise in productivity will depend on the change in compensation and the technology of production. The relationship between a change in the average wage and consequent changes in productivity through quality improvements may be developed more formally using a model in which worker quality enters the production process explicitly.[31] To begin, we assume quality affects the production process by augmenting the efficiency of the work force. In a standard two input framework this may be written as:

$$Q = f(K,bL) \tag{7}$$

where Q is output, K is capital input, and L is total hours worked. The efficiency index (b) is a function of labor quality:

$$b = g(M) \tag{8}$$

where M represents innate characteristics (e.g. mechanical aptitude). This specification makes clear the distinction between the level of quality and efficiency or productivity. While it is probably true that b is always an increasing function of M, there is no reason to suppose that labor quality enters every production process in exactly the same way; the shape of g(M) is likely to differ from one situation to another.

Given the production function the firm's optimization problem can be written:

$$\begin{aligned} &\max_{K,L,M} Z = PQ - rK - wL \\ &\text{s.t. } Q = f(K, bL) \end{aligned} \tag{9}$$

We assume that r is constant, but that w is an increasing function of M. Note that all workers are paid the same wage. Since the elasticity of substitution between workers of different quality is assumed to be infinite a rise in w results in complete substitution of higher for lower quality labor.[32] Thus, the level of M is the same for all workers.

The level of M the firm chooses depends on the following first order conditions:

$$Pb \frac{\partial Q}{(bL)} - w = 0 \qquad (10)$$

$$P \frac{\partial Q}{K} - r = 0 \qquad (11)$$

$$P\left[\frac{\partial Q}{\partial (bL)}\right] - \frac{db}{dm} - \frac{dw}{dm} = 0 \qquad (12)$$

Equations (10) and (12) yield

$$\frac{db}{dM}\frac{1}{b} = \frac{dw}{dM}\frac{1}{w} \qquad (13)$$

which determines the optimal level of M.

To illustrate the relation between productivity and an exogenous increase in the wage we specify the following simple functional forms for (7), (8) and the wage-quality function:

$$Q = AK^{\beta}(bL)^{1-\beta} \qquad (14)$$

$$b = BM^{\gamma} \qquad 0 < \lambda \qquad (15)$$

$$w = C + M^{\delta} \qquad 0 < \delta \qquad (16)$$

Using (15) and (16) and the reduced form expression for M from (13) we obtain an expression relating b and w:

$$b = B\left(\frac{\gamma}{\delta} w\right)^{\frac{\gamma}{\delta}} \qquad (17)$$

The elasticity of b with respect to exogenous changes in w (i.e. γ/δ) is the key parameter in the system. It determines the extent to which the firm can recover the incremental cost of an exogenous wage increase by hiring workers of higher quality. Stability requires $(\lambda/\delta)<1$, so that wages rise more rapidly than productivity for a given change in M. This makes good intuitive sense, since if it were not true, the firm could lower unit costs by raising the wage. Given stability, the elasticity is bounded by zero and one, since δ and γ are both positive. Whether the elasticity is close to either bound in a given situation will depend on technology and the wage-quality function facing the firm.

The model can be used to examine the effect of unionization on labor quality

and productivity. Assume that the introduction of collective bargaining raises w by ϕ percent. Because of contract rules and associated legal problems the firm cannot adopt the optimal level of M immediately.[33] Until the workforce has completely turned over, the firm will have both old (pre-union) and new (post-union) workers and the new workers will be of higher quality. Let the relative efficiency advantage (i.e., ratio of marginal products) of new workers be given by (1 + h), where

$$h = (\frac{\gamma}{\delta})\phi \tag{18}$$

The production process after unionization can be written

$$Q = AK^{\beta}[L_o + (1 + h)L_n]^{1-\beta} \tag{19}$$

where o and n indicate old and new respectively, and the efficiency index has been expressed in terms of the efficiency of old workers. Unionization also has organization effects, so that

$$A = A_1 (1 + d) \tag{20}$$

where A_1 indicates organizational aspects of the firm in the non-union era, and d is a measure of the union productivity effect. To simplify the analysis assume that β is not affected by unionization.

Since the production processes in the two regimes differ only by a constant, the union and non-union observations may be pooled using a simple union dummy. In logarithmic form we have

$$\ln(Q/L) = \ln A_1 + [d + hD(1 - \beta)] U + \beta \ln(K/L) \tag{21}$$

where $L = L_n + L_o$, $D = L_n/L$, and U takes on a value of one if the observations are drawn from the union era, and zero otherwise. The coefficient on the union dummy captures both organization effects and the influence of quality adjustments. The empirical analysis in section II assumed that $hD(1 - \beta) = 0$ so that the union coefficient could be identified with the organization effect (d). The magnitude of the bias induced by the assumption is an empirical question and depends on the values attached to labor's share ($1-\beta$), the efficiency advantage of new workers (h), and the proportion of new

workers in the total workforce (D).

To gauge the influence of omitted quality measures, evidence has been gathered on all three magnitudes. The share of production workers has been estimated in Clark (1979); for the purpose of illustration, we use a value of 0.45. Estimates of the other two parameters have been obtained in a less straightforward fashion. The efficiency advantage of new workers depends on the union wage effect (ϕ) and on the elasticity of efficiency with respect to changes in the wage (γ/δ). We have no information on γ or δ, beyond the condition $0< \gamma/\delta < 1$. Since our purpose is to obtain an upper bound on the quality effect, we have chose to use a relatively large value of 0.8.

Information on the proportion of new workers in the workforce has been obtained through case studies of unionization in the six cement plants, the full details of which are examined in the next section. Information in Clark (1978) suggests that the union wage effect falls in the range from 12 to 18 percent. Both values are used in the calculations below. To measure D in a given plant, estimates of the percentage of the 1976 workforce who were employed at the time the plant was unionized were obtained. The average value of D in 1976 in the six plant sample was .34 with a range from .05 to .65. This overstates the proportion of new workers relevant for present purposes. Since the estimated union effect is an average, D should be measured by an average value over the sample period. If D grows at a constant rate throughout the union era, then the estimated value at the midpoint of the period would be appropriate. Both the midpoint and the endpoint values will be used below.

Table 3 summarizes the assumed values of $(1-\beta)$, h and D and presents alternative calculations of the effect of quality on productivity. Columns 1 and 2 contain estimates of the quality effect for alternative values of h. These calculations support the conclusion that changes in quality are likely to have had a small effect on productivity. Under the most generous assumptions, quality improvements raise productivity by a little over two percent. Under more realistic assumptions about turnover,

Table 3

Calculations Illustrating the Effect of Quality Changes
on Productivity in the Before/After Sample

	Productivity Impact of Quality Change $q = (1-\beta)Dh$	
	(1) using upper bound estimate of union wage effect ($\phi = .18 \Rightarrow h = .16$)	(2) using lower bound estimate of union wage effect ($\phi = .12 \Rightarrow h = .11$)
(1) using proportion of new workers at endpoint ($D = .34$)	$q = .024$	$q = .017$
(2) using proportion of new workers at midpoint ($D = .17$)	$q = .012$	$q = .008$

Note: Quality effect = $(1-\beta)Dh$; $h = (\gamma/\delta)\phi$; in all calculations $(1-\beta) = .45$ and $(\gamma/\delta) = .8$.

the effect is close to one percent. These results suggest that while the estimated union coefficient in the empirical analysis may be an overestimate of the union productivity effect, the extent of the bias is quite small. Correcting for changes in quality leaves the basic findings intact.

Section IV: Case Studies of the Union Organization Effect

Within the framework laid out in section I unionization may lead to a variety of changes in the labor contract and the internal operation of the firm. The empirical evidence in section II suggests that adjustments consequent to unionization are, on balance, productive. Yet measurement of the impact of the union deals with only half of the issue. We argued earlier that the union effect arises through a complex process of organizational and behavorial change. A complete analysis requires not only measurement, but identification of the channels of union influence.

This section presents evidence from a series of case studies of the unionization experience in the six before/after plants. Through interviews with union and management officials we attempted to identify worker and management response to changes in the labor contract brought on by unionization. The interviews conducted were structured around the distinction between changes in contract provisions on the one hand, and the response or adjustment to the changes on the other hand. In the first phase of the interview we examined exisiting practices under the union contract in terms of compensation, internal mobility (promotions, transfers), exit and entry (hiring, layoffs), dispute settlement, technological change and work practices. The interviews were supplemented with evidence from written contracts. Once the procedures governing each category were clear, respondents were asked to contrast experience under collective bargaining with practice before unionizaton using the same categories.

The second phase of the interview dealt with responses and adjustments to changes in the rules. Information was sought from both union and management representatives on the behavior and adjustment of both groups. However, with management representatives, most of the second phase was devoted to a discussion of changes in management procedure and personnel, while the union interviews tended to focus on the grievance problem and the implicit contract in the non-union era. It was apparent from these discussions that retrospective interviews provide only weak evidence on the more subtle effects of unionization. Changes in morale and motivation, differences in work group efficiency, and the amount and quality of on-the-job training appear to be difficult to assess without carefully designed questionnaires administered before and after unionization, and without measurement and observation of the process in question.

Changes in the Labor Contract

Differences in the labor contract serve as necessary or enabling conditions for a union productivity effect. The extent of change in rules governing the employment relation is an important determinant of the scope and magnitude of union influence. Analysis of the labor contract thus serves as a useful check on the plausibility of the statistical analysis and the examination of adjustments in operations. Table 4 summarizes contract changes in the before/after plants following unionization.

The evidence on the labor contract under the union and non-union regimes reveals a fundamental change in rules covering exit and entry, internal mobility, and dispute settlement with a more moderate impact in compensation. The moderate union impact on compensation evident in line 1, is consistent with evidence on the union wage effect found in cross section data and with information obtained through interviews and discussions with union and management officials not connected with the before/after plants. The apparent increase in compensation occurs through a variety of forms,

Table 4

Changes in the Labor Contract

Contract Category	Non-union Practice	Union Practice
1. Compensation	explicit policy of matching or coming close to union rates; bonuses used in some cases to match union earnings; standard fringes available (paid vacation, insurance, pension); no penalty payments	increase in number of job classifications; improvements in fringe benefits; penalty payments (reporting, call out, etc); likely range of union effect on compensation: 12 to 18 percent (see Clark 1978)
2. Exit-Entry	hiring at bottom grade with some internal promotion; workers always on probation; outside hiring common for maintenance and other jobs; layoff and recall based on decision of foremen	hiring at bottom grade with internal promotion; probationary period of 30-90 days; internal programs to equip employees for maintenance jobs; outside hiring extremely rare for jobs above laborer; layoffs and recall plantwide, based on seniority
3. Internal Mobility	promotions by department; openings advertised informally (word of mouth); or by posting on bulletin board; no formal procedure; criteria for promotion not specified; decisions made by foremen; seniority not a governing factor	mobility according to job posting and bidding procedure; decison made by plant manager; plantwide seniority principle criteria
4. Dispute Settlement	no formal procedure; grievances discouraged; disputes dealt with by foremen or plant manager; no outside involvement of impartial parties	disputes handled through grievance procedure with outside arbitration

Source: interviews with union and management officials; union contracts

with direct adjustments in straight-time rates often assuming a minor role. Four of six plants followed a policy of paying union scale, and in one plant substantial bonuses were used to bring earnings on par with union plants. Even where union scale on existing jobs was paid, some change in the average wage occurred through changes in the number of job classifications, and in re-assignment of workers to different (i.e., higher) classifications, Fringe payments were less closely linked to the union contract, but even here, changes more often took the form of liberalizing the existing package rather than adding totally new benefits.

In contrast to compensation, somewhat greater changes occured in provisions governing entry and exit, and internal mobility. In both union and non-union settings a distinction is made between internal and external sources of labor. Under both regimes, promotion from within was the most common form of filling job openings, but the internal/external distinction was much looser in the non-union situation. We found a policy of hiring "outside" workers into maintenance jobs in every plant, and in three of the six plants, hiring from outside was practiced at all levels of the job structure. Furthermore, in situations involving internal mobility the scope of management discretion is broader and the rules governing internal movement were less explicit and specific than is the case in the union setting. Without the union, job mobility within the plant depended solely on the decisions of the department foreman or plant manager, with no restrictions on the process of matching workers and jobs. The criteria for making judgments about job requirements and qualifications were not explicit; we found no evidence of formal evaluation systems, or attempts to communicate management's views of ideal qualifications.

The contrast with the union setting is quite sharp. Internal mobility under collective bargaining is governed by a formal plant-wide job posting and bidding procedure, with explicit criteria for selection. Contracts in some of the plants contain provisions allowing management to take ability into account, but in practice plant-wide seniority is the principal factor. The existence of a formal procedure

with explicit criteria for choosing among workers has several organizational consequences. Perhaps the clearest change is the reduced role of management judgment. In the non-union setting, the foreman (or plant manager) decided both the criteria for filling jobs, and who met the criteria in a specific situation. Ability considerations were given greater weight in the non-union setting; but there is some evidence that personal factors also were taken into account. Union officials and some representatives of management generally agreed that personalities were important in determining who was promoted, and that foremen sometimes "played favorites." Whether such preferences came at the expense of ability, or whether personalities were important only in choosing among people of equal ability is not clear. It is fair to say, however, that the introduction of the union essentially eliminated personal considerations in decisions regarding post-hiring job mobility.

The changes in rules governing internal mobility underscore the fundamental shift in authority and power which occurs with unionization. The limits on management discretion are clearly revealed in line 4 which summarizes the different methods of resolving disputes in the union and non-union regimes. In each plant unionization was followed by the introduction of a formal grievance procedures with outside arbitration. The grievance procedure replaced a "system" in which worker's problems were dealt with in an ad hoc fashion. Prior to unionization, none of the plants in the before/after sample had regular channels of communication through which grievances or complaints could be expressed. Individuals with grievances had to raise them with supervisors, who heard the dispute and rendered judgement. In contrast to the union regime where too frequent use of the system is often a problem, information from both union and mangement officials suggests that in the non-union setting few problems were ever raised. The evidence implies that the absence of quarantees against recrimination was a strong deterrent.

Changes in the Behavior of Workers

For workers, the introduction of a grievance procedure and an increase in compen-

sation augur for adjustments of several kinds. In the interviews we sought to uncover evidence on changes in worker morale, as well as exit behavior, including permanent separations initiated by workers, absenteeism and subpar or disruptive work effort evidenced in discipline problems. The evidence available through the interviews is summarized in line 1 of Table 5 . The table presents a statement of prior expectations about worker/management adjustments in column 1, and evidence on observed changes in each of the six plants in columns 2-7. Unfortunately, neither survey data or measures of quit or absenteeism rates were obtained. As a result, the evidence on worker behavior is relatively weak. As the summaries in line 1a suggest, the interviews revealed a decline (3) or no change (2) in the quit rate in five of the six plants studied; in one plant quits were perceived to have risen. We found some evidence of an increase in absenteeism, and a decline in major discipline problems. In the main, these results are indicative of very moderate changes in exit behavior. It seems likely that had quits or absenteeism changed substantially, we would have uncovered much greater awareness of that adjustment. As it stands the interviews lead to the conclusion that reductions in turnover and other forms of exit behavior were not a principal connection in the union-productivity nexus.

The question of worker morale, examined in line 1b, was one of the few issues where substantial disagreement between union and management representatives emerged. In two of the plants examined, management officials felt that morale had declined or had not changed, while union representatives perceived definite improvements. In the four other situations, morale apparently improved in two and was not much affected in the others. These conclusions are based on impressionistic and perceptual information and underscore the point made earlier, that the interview format is not well suited to the analysis of morale and motivation. Although the changes in the labor contract provide strong prior grounds for expecting substantial changes in morale, there appears to be insufficient evidence to confirm or disprove those expectations.

Table 5

Adjustments to Changes in the Labor Contract in the Six Before/After Plants

Category	Expected Changes based on prior evidence (1)	Plant 1 (2)	Plant 2 (3)	Plant 3 (4)	Plant 4 (5)	Plant 5 (6)	Plant 6 (7)
1. Worker Adjustments							
(a) exit behavior	rise in compensation and increased voice in operation of workplace imply reduction in exit behavior	turnover lower; reduction in big discipline problems; increased absenteeism especially among younger workers; increase in small petty discipline problems	increases in quit rate; not much change in discharges or layoffs	no change in exit behavior	decline in quit rate; increase in absenteeism; no change in discipline problems	no change in absenteeism; quits and discharges reduced; big discipline problems less frequent	no change in exit behavior
(b) morale	greater voice, increased control over work conditions, reduction in apparent arbitrary decisions imply improvements in morale	definite improvement in morale	not much noticeable change (MGT); morale improved(UN)	morale deteriorated after union(MGT); morale improved (UN)	morale not much changed	definite improvement in morale	morale not much changed
2. Management Adjustments							
(a) non-union management style		paternalistic	paternalistic	authoritarian/ autocratic	authoritarian	authoritarian/ autocratic	professional
(b) changes in personnel	disparity in style and requirements for success in union setting imply change in management personnel (old dog/new tricks phenonenon)	new plant manager; gradual change in supervisor ranks	new plant manager; wholesale changes in foreman group	new plant manager; increased number of foremen	new plant manager additional supervisors; staff specialist in personnel and safety	new plant manager; reduced number of foremen; brought in in new industrial relations staff	new plant manager;new foremen
(c) practices/ procedures	greater involvement of union in operation of enterprise; increased compensation and need to cut costs imply efforts to "tighten ship"	established system of production targets and goals; review performance of supervisors; regular meetings with supervisors; "keep close eye on things"	changes in procedure directed by contract (e.g., discharges); no change in reporting or accountability	supervisors changed way they dealt with people; some gradual changes in system of monitoring performance	little change in procedures except as dictated by contract;supervisor-worker relations changed	some changes in reporting and accounting system; introduced staff meetings; major change in way supervisors dealt with people	introduced standards for department; new on line time standards for equipment; introduced meetings with supervisors

note: MGT = management view
UN = union view

Management Adjustments

The introduction of collective bargaining fundamentally changes the task of management. Managers are faced with constraints on old procedures and practices, and the processes of negotiation and contract administration constitute a reduction of management power. Decisions traditionally within the purview of management are often challenged as a matter of routine. The magnitude of the change which unionization entails depends on the style of management in the non-union era. As the summaries in line 2a suggest, in five of the six plants studied an essentially authoritarian management was confronted by a significant shift in power and authority. Previous methods, particularly the manner of handling and dealing with workers, were no longer viable (i.e., were much more expensive). The evidence suggests that successful management in the union context required new management procedures and practices. Perhaps the most cogent description of the differences in the management process before and after unionization was given by a plant manager who remarked:" . . . before the union this place was run like a family; now we run it like a business."

The major change in plant management uncovered in the interviews were introduced by a new plant manager, and in some instances, new supervisors. Given the substantial change in the nature of industrial relations, the identification of the old manager with the non-union regime, and the likelihood that previous management was involved in attempts to block unionization, the change in plant management is not surprising. While re-training permitted many front line supervisors to make the adjustment to a union regime, training was not a viable option in the case of plant managers. The interviews suggest that a new manager was in some sense a pre-requisite for innovation in management methods.

In most of the before/after plants, new management meant new procedures and practices. Before the interviews were conducted, changes in management procedure could be expected on theoretical grounds. Apart from capital-labor substitution and labor

quality adjustments, the union wage affect creates incentives for management to extract more work effort from a given level of employees. These expectations were clearly realized. As line 2b reveals, the interviews uncovered changes in management methods in all plants. The magnitude of the change varied from situation to situation, with a more professional, businesslike approach to labor relations by front line supervisors the most common adjustment. In four of the six plants we found attempts to increase work effort and work group efficiency primarily through introduction of formal methods of organizational control. The adjustments in formal control procedures took several forms. In essence, however, they amounted to a system of production goals or targets accompanied by procedures for the review and monitoring of performance. The evaluation often occured in newly introduced staff meetings, which were used for communication, training, and assessment of conditions and progress. Substantial changes in formal procedures were not introduced in all plants. Yet, even where formal procedures were changed only moderately, the interviews suggest that management monitored work performance and manning requirements more closely.

Taken together, the evidence summarized in Table 5 suggests that unionization led to substantial changes in mangement in each of the before/after plants. Not all adjustments noted were observed in all plants, but each plant experienced change in a number of dimensions. The existence of a pattern of management adjustment across plants organized at different points in time, suggests that the observed changes are not due solely to general technical change. While technical change may be at work in the processes we observed, it seems clear from the interviews that unionization had a significant independent effect. Our tentative conclusion, therefore, is that an improvement in plant management is one of the key adjustments to unionization. These results may be interpreted as evidence of a modern union "shock effect." The institutional analysis is consistent with a broad range of earlier studies on the effects of unionization and provides a partial explanation of the union effect estimated in section II.

Section IV: Conclusions and Implications

The examination of collective bargaining and productivity in this study has yielded empirical results on the magnitude of the union productivity effect, and the case studies have provided some insight into the channels through which unions influence productivity. The empirical evidence suggests that unionization leads to gains in productivity of 6-8 percent. The finding appears to be relatively robust with respect to model specification and adjustments for changes in labor quality and other omitted factors. While the evidence is indicative of productive changes in operations after unionization, the precision of the estimates suggests caution in drawing conclusions about exact orders of magnitude.

Similar caution applies to the institutional analysis. It is clear from the evidence in section III, that additional information on worker behavior is needed before definitive conclusions about the union effect may be drawn. It does appear that unionization leads to fundamental changes in the labor contract, which may lead to changes in the behavior of workers and managers. The available evidence, however, provides a reasonably clear picture only about management adjustments. In most of the plants studied, we found significant changes in the style and substance of management. Observed changes ranged from introduction of staff meetings, to on line time standards for equipment maintenance. These results support the conclusion that unionization significantly alters the processes of management. Union effects which work through other channels--i.e. exit behavior, work group effectiveness--are less subject to analysis through interviews, and evidence from the case studies is essentially weak and inconclusive.

The results of the cement industry analysis have important implications for understanding the function and impact of the union, and for questions of organizational change and productivity. The finding that unionization induces an increase in productivity implies that reductions in efficiency which follow capital-labor substitution are offset to some extent by organization effects. Thus, the efficiency effects of the union may be much different than previously supposed. The question of overall efficiency is, of course, much broader than adjustments made by the firm, and the effect of unions on productivity is only one aspect of the overall impact of the union. Moreover, it is likely that the effect of unionization will be different in different situations.

The processes of adjustment observed in the six plants seem to be consistent with evidence from the organizational behavior literature on the determinants of successful organizational change.[34] Without examples of organizational failure, however, it is difficult to draw conclusions about the specific circumstances and policies which lead to successful adaptation. Further research on the process of unionization in diverse industrial settings is essential to a deeper understanding of the problem. Not only might further study sharpen our understanding of the operation and broad consequences of the union, but it may yield insights into the general processes of organizational change and adaptation and thus contribute to the development of public and private policies to enhance productivity.

Footnotes

1. The basic reference is Slichter, Healy and Livernash (1960).

2. See the papers by Brown and Medoff (1978), and Frantz (1976).

3. A review of the pre-1970 literature may be found in Bok and Dunlop (1970). A more theoretically oriented discussion is presented in Brown and Medoff (1978) and Clark (1978).

4. The capital-labor ratio is understood to be adjusted for differences in quality. The traditional channel of union influence is discussed in Johnson and Mieskowski (1970), and in the paper by Lewis in Bradley (1959).

5. This effect assumes the existence of unexploited opportunities to increase profits and is, therefore, closely related to the concept of X-efficiency developed by Leibenstein; see Leibenstein (1976) for an extended analysis.

6. See Freeman (1976) for a statement of the "exit-voice" model of the union.

7. This effect is discussed in Williamson, Wachter and Harris (1975).

8. Research in organizational behavior suggests that there is no necessary link between morale and productivity. However, it does appear that morale problems may inhibit performance, even though high morale need not lead to high performance. Moreover, the link between motivation and productivity is quite strong, and is affected by workers' perceptions See Lawler (1973).

9. See Radner (1975) for an analytical treatment of managerial behavior governed by bounded rationality and satisficing which are implicit in this sentence.

10. This problem greatly complicates inferences based on comparison of value added per hour worked. Brown and Medoff (1978) have shown that if cost differences are fully reflected in differences in prices, the estimated union coefficient in their model identifies only a price effect.

11. See Brown and Medoff (1978) for an illustration of the ambiguity introduced by potential differences in technology.

12. The point is that observable characteristics (age, sex, race, education etc.) may be poor indicators of the "true" attribute of interest (e.g. mechanical aptitude). Thus hedonic wage equations, which are often used to capture quality differences, may be subject to serious bias due to omitted (unobservable) variables. See Brown and Medoff (1978) for an application of quality adjustments based on wage equations.

13. While the Cobb-Douglas form is restrictive, evidence presented in Clark (1979) suggests that the form of the production function has little affect on inferences about the union differential in the cement industry.

14. The formulation in (3) rests on the approximation

$$\ln (1 + x) = x$$

15. Sources of information on the cement industry include Loescher (1959), Lesley (1924), Hadley (1945) and Hilts (1938).

16. The median shipping distance in 1976, for example, was 90 miles; see U.S. Department of Commerce, Construction Review (June 1976).

17. Information on unionization is based on the records of the Cement Employers Association, and the United Cement, Lime and Gypsum Workers International Union.

18. For information on average employment per establishment see the Census of Manufacturers, table 32B-15, and p. 1-98 of the General Summary, 1972.

19. Bureau of Labor Statistics, Employment and Earnings - Historical Statistics 1909-1975.

20. Bureau of Labor Statistics, Employment and Earnings, January 1977.

21. ASTM stands for American Society for Testing Materials. There are 10 types of cement recognized by the ASTM, each specified according to minimum quality standards.

22. The PCA survey covers about 80 percent of the industry. The composition of the overall sample varies slightly from year to year, but there appears to be no systematic variation in participation by region, union status, size or productivity.

23. The use of equipment capacity to measure the stock of capital is common in studies of electricity generation. See Nerlove (1963) for references to the basic literature.

24. See Mundlak (1963) for a discussion of this issue.

25. An alternative specification is provided by a variance components model. A key assumption of that model, however, is that the firm specific component is a random variable, and hence uncorrelated with other explanatory variables. The issue of bias is thus assumed away.

26. One of the plants in the sample was organized following its acquisition by a larger cement producer. For this establishment we may be confounding the effects of unionization with the effects of acquisition. However, dropping this plant from the sample did not change the basic results studied in several specifications the estimated union effect was significantly larger.

27. There is some question as to how to define union status. Many of the affects of unionization could conceivably be felt with the organization of local chapter of the union; some of the effects would follow the recognition of the union as the collective bargaining agent; while others would require the signing of a contract. In the results reported here, the union dummy takes on a value of one in each year following the year in which the local was chartered by the international, if less than six months elapsed between chartering and the end of the year. If more than six months elapsed, the year of charter also received a value of one.

28. Under the specification in line 1, for example, the capital coefficient was .137(.132) and the coefficient on $\ln L$ was -.336(.186).

29. The problem is similar to the difficulty encountered in estimating the effects of training programs. An important distinction is that the "treatment" (i.e. unionization) occurs at different points in time in the present instance.

30. The regional correction is only a very rough measure of the influence of common factors. The appropriate measure would seem to be average productivity of plants of similar vintage in the region. Our measure of regional productivity does not distinguish plants on the basis of vintage. The estimate of regional productivity is based on data available from the PCA. In the early years it includes plants older than the before/after sample, and new plants in the later years. The effect is to raise the average rate of regional productivity growth.

31. This model has been used extensively; see Ashenfelter and Johnson (1972).

32. More sophisticated models might allow for less than infinite substitutability between workers of different quality. The result would be to reduce quality adjustments.

33. It might be supposed that the firm would anticipate the inability to adjust immediately, and compensate by hiring workers above the optimal level. But the wage rule obviates such behavior, since all workers would have to be paid the necessarily higher wage. In addition, the higher wage would become the floor in future collective bargaining.

34. Greiner has suggested that successful changes in organizations involve the presence of compelling internal or external pressure, the intervention of a leader from outside the organization who acts as a catalyst, a thorough re-examination of operations and problem solving through shared authority or power. While not a reflection of the ideal in all respects, the unionization process in the six plants is broadly similar. See Clark (1978) and Greiner (1967) for a discussion of these issues.

BIBLIOGRAPHY

1. Ashenfelter, Orley and George Johnson, "Unionism, Relative Wages and Labor Quality in U.S. Manufacturing Industries" International Economic Review, October, 1972.

2. Brown, Charles and James L. Medoff, "Trade Unions in the Production Process" Journal of Political Economy, (June, 1978).

3. Bok, Derek and John T. Dunlop, Labor and the American Community (N.Y., 1970).

4. Bradley, Philip ed. The Public Stake in Union Power (Charlottesville, 1959).

5. Clark, Kim B., "Unions and Productivity in the Cement Industry," Unpublished Ph.D. dissertation, Harvard University, 1978.

6. _____"Unionization and Productivity: Micro-Econometric Evidence" NBER Working Paper No.

7. Frantz, John, "The Impact of Trade Unions on Productivity in the Wood Household Furniture Industry," process (June, 1976).

8. Freeman, Richard B., "Inidividual Mobility and Collective Voice in the Labor Market," American Economic Review, (May, 1976).

9. Greiner, Larry C., "Patterns of Organization Change" Harvard Business Review, 1967.

10. Hadley, Earl J., The Magic Powder, (New York, 1945).

11. Hilts, H.E., The Manufacturing, Volume, and Costs of the Portland Cement Industry in the United States, (Washington, D.C., 1938).

12. Johnson, Harry and Peter Mieszkowski, "The Effects of Unionization on the Distribution of Income: A General Equilibrium Approach," Quality Journal of Economics, November, 1970.

13. Lawler, E.E., Motivation in Work Organizations, (Monterey, 1973).

14. Leibenstein, Harvey, "Allocative Efficiency vs. 'X-Efficiency'" American Economic Review, June, 1966.

15. Lesley, Robert W., History of the Portland Cement Industry in the United States, (Chicago, 1924).

16. Loescher, Samuel M., Imperfect Collusion in the Cement Industry, (Cambridge, 1959).

17. Mundlak, Yair, "Estimation of Production and Behavioral Functions from a Combination of Cross-Section and Time Series Data" in C. Christ ed., Measurement in Economics (Stanford, 1963).

18. Nerlove, Marc, "Returns to Scale in Electricity Supply" in C. Christ, ed. Measurement in Economics, (Stanford, 1963).

19. Radner, Roy, "A Behavioral Model of Cost Reduction," Bell Journal of Economics, (Spring, 1975).

20. Slichter, Sumner, James Healy and Robert Livernash, The Impact of Collective Bargaining on Management, (Washington, D.C., 1960).

21. U.S. Department of Commerce, Construction Review, (June, 1976).

22. Williamson, O., Jeffrey Harris and Michael Wachter, "Understanding the Employment Relation: The Analysis of Idiosyncratic Exchange," Bell Journal of Economics, (Spring 1975).