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RULING OUT PRODUCTIVITY?
LABOR CONTRACT PAGES AND PLANT PERFORMANCE

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ABSTRACT

This study documents a strong inverse relationship between number of pages of labor contracts in effect and the productivity observed in a sample of ten unionized plants. It is argued that this relationship reflects the productivity-inhibiting effects of increases in the number and complexity of work rules. The study also argues that subsequent research should try to improve the measurement of work rules by considering the substance of the rules and which parameters of a production function the rules are likely to affect.

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I. Introduction

Despite a growing number of studies that document a significant positive relationship between union status and productivity,[1] a number of criticisms remain unanswered. Among these complaints, one of the most frequently voiced by managers is that unionized establishments operate under more restrictive work rules and practices and that other potential gains of unionization, lower turnover rates or formal grievance machinery, for example, could not outweigh the inefficiency associated with these added restrictions. Despite the frequency with which this complaint is raised, no direct empirical studies on the relationship between work rules and productivity have been made. The few studies that have been conducted, address this issue indirectly by focusing on differences in substitution parameters obtained from equivalent union and nonunion production functions.[2] This study takes a first step in analyzing the relationship between work rules and productivity in a more direct fashion.

In this study, monthly data from January 1976 to September 1982 on the operations of eleven paper mills are analyzed. The number of pages in collective bargaining agreements is taken as a directly measurable proxy for the number and complexity of work rules. This proxy for the extent of work rule regulation is then considered within the framework of a detailed, plant-level production function to gauge the differences in productivity associated with changes in the contract page measure.

The analysis is developed in the following five sections. The next section presents the production function framework and describes the contract pages variable. Section III presents estimates of the productivity-contract pages relationship obtained from this production equation. Section IV considers several other variables that might also indicate differences or changes in work rules and practices within the production equation. The empirical analysis is expanded in Section V by considering data for a nonunion mill. In this section, an average productivity difference between this mill and the ten unionized mills is calculated. While this mill has no collective bargaining agreements, contract pages values are predicted from the basic equation estimated in Section III and input-output data for the nonunion mill. Finally, the conclusion summarizes the results and argues for two improvements on the design of this study: improvements in the measurement of work rules; and suggestions for improving the model of how different types of work rules might affect the production process, thereby altering the parameters of the production function.

By way of preview, a significant inverse relationship between plant productivity and contract pages is documented. The estimated "output-contract pages elasticity" is -.068. Additionally, several periods when work rules are likely to be changing or in dispute are shown to be extremely unproductive periods of plant operation. Specifically, around the time of contract negotiations, and around the time that new machinery is installed, the plants produce significantly less output than one would expect given the stated level of inputs. Finally, by using input-output data for a nonunion mill, an implicit number of contract pages is predicted for a mill that has no collective bargaining agreements. On average, this mill's productivity is 9.5% below that of the unionized mills in the sample.

II. SPECIFICATION OF THE PRODUCTION PROCESS AND INPUT-OUTPUT DATA

With the aid of on-site investigations of each mill's production process, the production function given by equation 1 was developed to account for variations in productivity in these mills:[3]

$$\ln Q = \beta_o + \sum_{i=1}^{3}(\beta_{1i} \cdot KD_i) + \sum_{i=1}^{9}(B_{2i} \cdot KV_i) + \sum_{i=1}^{3}(B_{3i} \cdot PMD_i) + \sum_{i=1}^{4}(B_{4i} \cdot PMV_i) + (\beta_5 \cdot L) + (\beta_6 \cdot E) + \varepsilon \qquad \text{(Equation 1)}$$

Where: Q = tons of physical output;

KD_{1-3} = three plant dummies to control for two major product differences (white paper vs. newsprint; sheeted vs. not sheeted) and one major process difference (make vs. buy pulp) across the eleven mills;

KV_{1-9} = total depreciated, deflated value of assets in nine distinct categories of assets;

PMD_{1-3} = a set of three related dummy variables to describe whether a plant is operating two, three, four, or five or more paper machines (the two paper machine category is omitted);

PMV_{1-4} = total depreciated, deflated value of the two, three, four or five plus paper machines;

L = labor input

E = energy input

The KD variables provide a direct control for major product and process differences observed in these mills. The more conventional method of constructing a value added index is particularly difficult in these mills.[4] The PMD variables provide some control over scale of operations. The KV and PMV variables are fashioned to recognize the principles of input aggregation for a heterogeneous capital stock.[5] For example, three categories involving energy generation capital, certain land and buildings, and pollution and recycling capital are not a direct part of the machinery that acts upon the raw materials flowing through the process. These categories of capital, then, are kept separate from other categories of capital that is part of the production process. The capital value variables are constructed from each mill's monthly asset inventory which contains information on the current value of each asset. In any month, there are some 15,000 assets that were allocated to these different categories of capital. L is defined as the natural logarithim of hourly manhours. E is the natural logarithm of BTU's used in production.

This unconventional specification is developed to provide an accurate model of the production processes in these mills. Equation 1 accounts for over 95% of the total variation in production in this sample. More conventional functional forms produce several nonsensical coefficients. For example, in a Cobb-Douglas function, with capital inputs specified as one net investment variable, the coefficient on capital is in fact negative for this set of plants in which capital plays the central role in transforming raw materials into final goods. More conventional forms explain a much smaller proportion of the total variation in output.[6]

In this study, total pages of collective bargaining contracts in effect, CONPAG, will serve as the proxy for the extent and complexity of workrule regulation in the mills. This is not an entirely satisfactory measure for several reasons. It's most noticeable shortcoming is that it does not capture the substance of the rules and practices in effect. Even setting aside this concern, longer contracts may not necessarily mean more rules. Sidebar agreements not incorporated in the contracts, rules set forth in arbitration decisions, or unwritten shop floor practices will not be captured by this meausure. These other sources of work rules may not necessarily increase with contract pages. Still CONPAG is a direct measure and should provide information on work rules since labor contracts are a major source of work rules. During 1976 to 1982, each of the ten unionized had either three or four contract cycles. The average number of pages in effect across all ten unionized mills over the seven year period is 195 pages. The fewest number of pages ever in effect in these mills is 68 pages; the maximum 465 pages. The lowest mill average is 78 pages; the largest mill average is 379 pages.

While the format and layout of the collective bargaining agreements is similar from mill to mill, there are slight layout variations across mills. To parcel out these plant-specific differences in the plants' contract formats, a complete set of plant dummies, will replace the dummy variables described in Equation 1, (KD_{1-3} and PM_{1-4}) that control for differences in products and processes across plants. With this modification and the addition of the CONPAG variable, the final specification becomes:

$$\ln Q = \beta_o + \sum_{i=1}^{9} (\beta_{1i} \cdot \text{PLANT}) + \sum_{i=1}^{9} (\beta{=}i \cdot KV_i) + \sum_{i=1}^{4} (\beta_{3i} \cdot PMV_i) +$$

$$(\beta_4 \cdot L) + (\beta_5 \cdot E) + \beta_6(CONPAG) \qquad \text{(Equation 2)}$$

where CONPAG will also be entered in logarithmic form.

Even if CONPAG does measure the extent and complexity of work rule regulation, the relationship between productivtiy and the extent of work rule regulation might not be described by the log-linear model of Equation 2. For example, some degree of work rule regulation may promote efficient operations, while an overabundance of rules might hinder efficiency. Therefore, the equation 2 model will be expanded to include the square of the natural logarithim of CONPAG.

III. Empirical Results: The Contract Pages-Productivity Relationship

When the equation 2 specification is estimated, the results in Table 1 are obtained. From the column 1 model, one sees that the overall relationship between contract pages and output, controlling for variations in the levels of productive inputs, is negative and significant. The estimated "output-contract pages elasticity" is -.068. However, from the coefficients in column 2, one observes that there appears to be some curvature in the contract pages-productivity relationship. These coefficients suggest that output at first decreases with additional contract pages; after some inflection point, output increases with additional contract pages. To solve for the value of this inflection point in units of contract pages, one can use the column 3 specification and solve the following equation for CONPAG:

$$\frac{\partial Q}{\partial \text{CONPAG}} = (-3.3\text{ E-3}) + 2(5.1\text{ E-6}) \cdot (\text{CONPAG}) = 0$$

The inflection point occurs at 324 contract pages. The vast majority of values of the contract page variable are below 324 pages. Those that do exceed 324 pages (only five of the thirty-five values of the contract page variable) tend to cluster near the inflection point of 324 pages.

To illustrate the nature of the relationship between contract pages and productivity in this sample, the results in Table 1 are presented graphically. Figure 1 uses the coefficients in the column 3 specification to evaluate $\partial Q/\partial \text{CONPAG}$ for each value of the contract page variable in the sample (as indicated by the open dots). Except for the two largest contract pages values (CONPAG = 390, 465), the inverse relationship between contract pages and produc-

Table 1: Contract Pages Coeffiecients in Production Function[a]
[Dependent Variable: ln Tons of Paper; N = 626]

	(1)	(2)	(3)
1. ln contract pages	-.068* (.043)	-3.013*** (.453)	——
2. (ln contract pages)^2	——	.276*** (.042)	——
3. contract pages	——	——	-3.3 E-3*** (0.6 E-3)
4. (contract pages)^2	——	——	5.1 E-6*** (0.9 E-6)
5. plant dummies and other input controls in equation 2 Specification	yes	yes	yes
R^2	.959	.962	.961

a - standard errors in parentheses

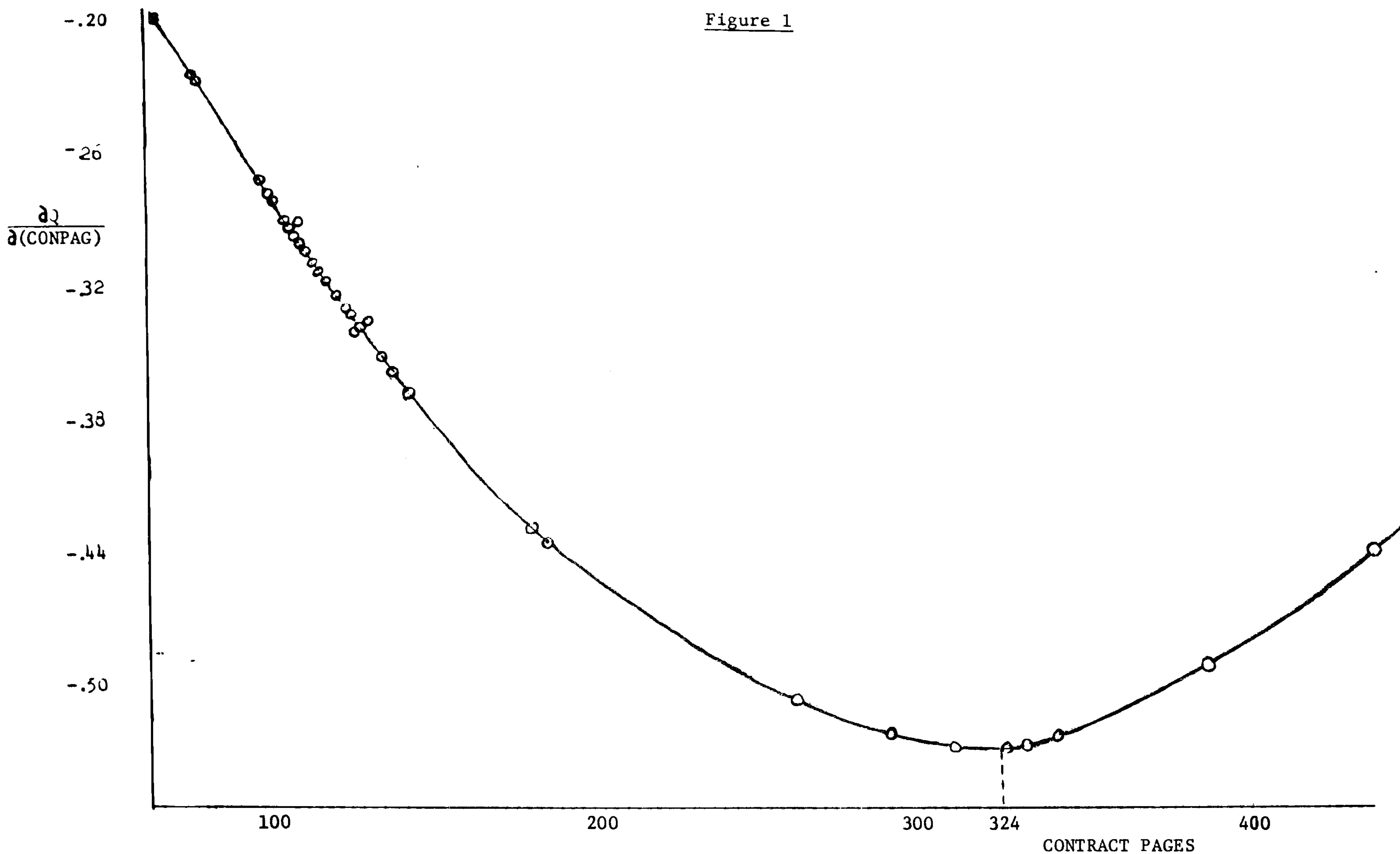
*** - significant at the .01-level, one-tailed test

** - significant at the .05-level, one-tailed test

* - significant at the .10-level, one-tailed test

tivity holds for virtually the entire range of contract page values. Given the small number of observations to the right of the inflection point in Figure 1, and the imperfect nature of contract pages as a measure of work rules, it would seem unreasonable to extend the positive contract page-productivity relationship beyond the range of observed values. Again, the simple linear "output-contract pages elasticity" is significant and negative (-.068). Probably the most reasonable conclusion one should draw from these data is that contract pages provides some information on the extent of work rule regulations and that there exists an inverse relationship between work rules and productivity, holding fixed the levels of other productive inputs.

Figure 1



-.20
-26
$\frac{\partial Q}{\partial (CONPAG)}$
-.32
-.38
-.44
-.50
100
200
300
324
400
CONTRACT PAGES

IV. Changing Work Rules: New Contracts and New Machinery

While the results of the previous section provide some support for the claim that increased work rule regulation inhibits productivity, it may be that the process of changing work rules also affects a plant's efficiency. Two sets of variables are constructed to measure periods when work rules come under pressure to change. First, a set of four dummy variables is created to describe each plant's contract cycle: the quarter before negotiations without a strike; the quarter after negotiations without a strike; the quarter before a strike; the quarter after a strike; and the omitted group of months from the central period of contract administration. Second, there is a set of variables to describe the periods when four major machines were installed in these mills during this seven year period. One variable is created for the six month installation period; a second for the first six months of operating the new machinery.

A number of different forces may be operating during these periods to influence how efficiently the plants are operating. Before negotiations, managers may try to speed up production to build inventories of standard products thereby dampening the economic power of the union during a possible strike; employees may try to reduce output for the opposite reasons. After negotiations, particularly if a strike occurred, the plant may not be operating efficiently as it tries to adapt to the new agreements put in place during negotiations. Conversely, after negotiations without a strike, there may be a honeymoon period in which employees operate the plant at higher efficiency levels.

For the new machinery variables, the installation of a major piece of capital may disrupt existing plant operations. After the capitalization date, the plant's capital variables are increased by the full purchase price. This may overstate the value of the capital in its early stages of operations for several reasons. First, a learning curve effect may exist as operators learn how to operate the machine. Second, and directly related to the work practices in the plant, the jurisdiction over any new work may be in dispute as old work rules fail to cover the new situation in the plant. As these issues are sorted out, the machinery may not be operating fully. Finally, it may simply take several months to integrate new machinery into the existing production process.

When the new variables are added to the previously estimated equations, the results in Table 2 are obtained. The addition of these new sets of variables leave the contract pages coefficients virtually unaffected. The simple output--contract pages elasticity is still -.068 (column 1). The addition of the squared contract pages term improves the specification and the same pattern of curvature in the output-contract pages relationship seen in Table 1 still exists (column 2).

The coefficients in lines 3a-3d, describe the relative levels of productivity during the periods when the number and substance of the contract pages are changing. These coefficients reveal that the periods around the time of negotiations are relatively productive periods given the stated levels of inputs. The most significant among these positive coefficients is the period

Table 2: Contract Page, Contract Cycle, and
New Machinery Coefficients in Production Equation[a]
[Dependent Variable: ln Tons of Paper; N = 626]

	(1)	(2)
1. ln contract pages	-.068*	-2.753***
	(.044)	(.454)
2. (ln contract pages)^2	———	.252***
		(.042)
3. Contract cycle variables		
a. quarter before negotiations	.023	.028*
	(.021)	(.020)
b. quarter after negotiations	.059***	.046**
	(.022)	(.021)
c. quarter before a strike	.041**	.034**
d. quarter after a strike	.010	.015
	(.019)	(.019)
4. New machinery variables		
a. six-month installation period	-.103***	-.088***
	(.032)	(.031)
b. six-month after	-.066**	-.058**
	(.036)	(.035)
5. Plant dummies and other input controls in Equation 2 specification	yes	yes
R^2	.961	.963

a - standard errors in parentheses

*** - significant at the .01-level, one-tailed test

** - significant at the .05-level, one-tailed test

* - significant at the .10-level, one-tailed test

after negotiations without a strike (line 3b) - possibly signalling some honeymoon period; and the quarter before strike - possibly signalling the efforts of management to build up inventories before the strike.

The coefficients in lines 4a and 4b, on the other hand, show the periods around the introduction of new machinery to be quite unproductive periods. The installation period (line 4a) is from 8.8% to 10.3% less productive than normal given the stated level of inputs. After installations (line 4b), productivity is 5.8% to 6.6% below what would be expected given the level of inputs in place. While the installation of major pieces of machinery is likely to disrupt the existing production process, the post-capitalization period may be relatively unproductive for a combination of reasons. Work practices may need to be adjusted in the face of the new operating needs of the plant; employees may need several months to learn how to operate the equipment effectively; the capital itself may not be well integrated with the production process.

Despite the significant effects of these sets of variables on production, the contract pages - productivity relationship remains unaffected: for most of the range of values for the contract page variable, output declines with more contract pages. The simple output-contract pages elasticity remains significantly negative at -.068.

V. Estimating Contract Pages for a Non-Union Firm.

Monthly data for one nonunion mill were also available in this sample. However, without negotiated agreements, it could not be incorporated in the preceding analysis. Still, these data can be incorporated in another way. First, by estimating the equation 1 specification without plant dummies, and only one additional dummy for the nonunion mill, the average difference between this mill and the ten unionized mills can be gauged. This analysis reveals that the nonunion mill is on average 9.5% less productive than the union mills for the stated level of productive inputs. The coefficient is significant at conventional levels and in keeping with the union productivity effects estimated in other studies.

Second, the coefficients obtained in the model in column 1 of Table 1 can be used to estimate an implicit number of contract pages for each month for the nonunion mill.[7] Simply, by evaluating that equation for the input-output values observed in the nonunion mill, the predicted contract page values are obtained:

$$\widehat{CONPAG}_{nu} = \frac{\ln Q_{nu} - (a + \beta \vec{I}_{nu})}{\beta_{CONPAG}} \qquad \text{(Equation 3)}$$

where $\widehat{CONPAG}_{nu}$ = predicted nonunion contract pages

Q_{nu} = output data from nonunion mill

$\vec{I}_{nu}$ = input data from nonunion mill

β, β_{CONPAG} = estimated coefficients obtained in Table 1, column 1 specification using data from sample of unionized firms.

Since the nonunion mill is 9.5% less productive than the union mills, the estimated contract page values for the nonunion mill will tend to exceed the contract page values observed in the union mills. That is, this -9.5% nonunion differential will be attributed entirely to increased numbers of contract pages. While it may be more reasonable to suspect that a number of other factors omitted from the basic production model are partly responsible for the observed productivity differential between the nonunion mill and its unionized counterparts, the analysis provides a useful illustration. It illustrates how much one would have to exaggerate the effect of contract pages on productivity to account for the entire union productivity differential.

When this analysis is performed, and the nonunion productivity differential is attributed solely to a greater number of contract pages, an implicit number of contract pages for each month is estimated for the nonunion mill. The average value for the estimated ln contract pages variable is 15.27. The average value for ln contract pages among the union mills is only 5.08. For the entire nonunion productivity differential to be accounted for by the effect of contract pages, the implicit number of "nonunion contract pages" would have to far exceed the number of contract pages in the unionized mills.

The size of this differential in contract pages indicates that other factors would also seem to be responsible for the observed union productivity differential. Still, it may not be unreasonable to consider the nonunion mill as having a much less efficient set of work rules than the union mills. Specifically, by not having rules well specified in explicit negotiated agreements, more confusion about operations may in fact exist in the plant.

Furthermore, there is some evidence that work rules proliferate as a plant ages.[8] The nonunion mill is one of the oldest establishments in the sample. The combination of proliferation of informal work practices as the mill ages coupled with an inability to use one principal source (a labor contract) as an official statement of those practices may be a serious obstacle to efficient operations.

VI. Conclusion

This study documents a significant inverse relationship between contract pages and productivity for a sample of unionized plants. While the introduction of a squared contract pages term in the production equation indicates a positive output-contract pages relationship among the few large contract page values, the negative relationship holds for most of the range of contract page values.

The absence of a uniformly negative relationship between contract pages and productivity is likely due to several shortcomings of this study that future research on this topic should attempt to remedy. First, contract pages, while a directly measureable proxy for work rules, is far from the ideal measure. Other sources of work rules (arbitration rulings, sidebar agreements, and informal practices) need to be considered.

More importantly, the substance of work rules and how they interact with other inputs in the production function need to be modelled directly. Many work rules probably alter substitution parameters; for example; limitations on introducing labor-saving devices, limit capital-labor substitution. Other rules may increase the number of inputs that need to be specificed. For example, if there are jurisdictional boundaries between operating and maintenance jobs, one would want to specify the labor input as two components with substitution limited according to how often the jurisdictional boundaries can be crossed.

Finally, it seems reasonable to expect that management supervision is a critical variable omitted from the above analysis. With low levels of supervision, more work rule regulation would probably be beneficial to efficient plant operations. For increased levels of supervision, rules would inhibit managers ability to deploy resources as it sees fit.

While providing some direct evidence of a inverse relationship between contract pages and productivity with analysis of unique plant-level data set, the results highlight a long list of questions that can only be addressed with an even more detailed set of data on plant operations and the nature and substance of the work rules that govern those operations.

FOOTNOTES

1. For a review of these studies, see Freeman, Richard B. and J.L. Medoff, "Trade Unions and Productivity: Some New Evidence on an Old Issue," NBER Working Paper No. 1249, Cambridge, Massachusetts, (December 1983).

2. Allen, Steven G., "Union Work Rules and Efficiency in the Building Trades," Mimeograph, North Carolina State Univeristy, Department of Economics, (August 1983); Freeman, R.B. and J.L. Medoff, "Substitution Between Production Labor and Other Factors in Unionized and Nonunionized Manufacturing," Review of Economics and Statistics, Vol. 64, no.2 (May, 1982), pp. 220 - 233.

3. Ichniowski, Casey, "Micro Production Functions Aren't Pretty: Firm-Level and Industry-Level Specification for Inputs and Outputs," NBER Working Paper No. 1365, Cambridge, Massachusetts, (June, 1984), pp 6 - 16.

4. Ibid., pp. 8-11.

5. Ibid., pp. 11-13.

6. Ibid., pp. 19-21.

7. The coefficients from the column 2 specification were also used to estimate the implicit number of contract pages in the nonunion mill by solving for the roots of the quadratic equation. However, for every observation, the value under the square root in the quadratic formula, $\frac{b \pm \sqrt{b^2 - 4ac}}{2a}$ is always negative.

8. McKersie, Robert B. and Janice Klein, "Productivity: The Industrial Relation Connection," M.I.T. Sloan School of Management Working Paper No. 1376-82, Cambridge, Massachusetts (Novermber, 1982), Appendix pp. 7-11.