HARRY C. KATZ
Cornell University

THOMAS A. KOCHAN
Massachusetts Institute of Technology

JEFFREY H. KEEFE
Rutgers University

Industrial Relations and Productivity in the U.S. Automobile Industry

IN THE LATE 1970s and 1980s intensified international competition in motor vehicle manufacturing and sales was reflected by an increase in the share of the American market captured by imports.[1] Some analysts argued that this increase reflected the low productivity of American automobile producers compared with that of Japanese and other foreign companies. Inflexible work rules or the adversarial nature of labor-management relations was often blamed.[2]

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1. Imports rose from 15.2 percent of passenger car sales in the United States in 1970 to 28.3 percent in 1986; *Ward's Automotive Yearbook* (Detroit: Ward's Communication, 1971), p. 57; (1987), p. 194.

2. William J. Abernathy, Kim B. Clark, and Alan M. Kantrow estimated that U.S. automakers required 1.61 times the labor used by Japanese firms to produce a small car in 1981; see *Industrial Renaissance: Producing a Competitive Future for America* (Basic Books, 1983), p. 61. Using data from the level of the individual firm to estimate a multiproduct cost function and factor demand equations, Clifford Winston and others found Japanese labor 1.36 times more productive than American labor in automobile production; see *Blind Intersection? Policy and the Automobile Industry* (Brookings, 1987), p. 16. Also see Alan Altshuler and others, *The Future of the Automobile* (MIT Press, 1984). J. R. Norsworthy and Craig A. Zabala estimated that U.S. auto companies lost

The managements of the American auto companies apparently accepted the proposition that industrial relations practices on the shop floor contributed significantly to their competitive problems. In the 1980s they argued that better practices were necessary to avoid layoffs and further erosions in market share.[3] Often their arguments led to changes in industrial relations that gave managements greater discretion in allocating workers (and lessened the power of formal negotiated rules), increased the pace of work, and attempted to facilitate greater cooperation between management and the work force.[4] These new work rules and the pay concessions that often accompanied them received wide attention in the press, in part because the auto industry had been the pacesetter in collective bargaining since World War II.[5]

American management generally focused its efforts to improve shop floor practices on reducing the number of job classifications, hoping that such reductions would lead to lower costs. In a number of plants they pressed for the introduction of team systems of work organization and a lessening of the importance of seniority rights in intraplant transfers and promotions.[6]

The auto industry's efforts to improve competitiveness by changing industrial relations practices likely will continue as a result of new

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between \$2 billion and \$5 billion in profits in the 1970s because of poor industrial relations; see "Worker Attitudes, Worker Behavior, and Productivity in the American Automobile Industry, 1959–1976," *Industrial and Labor Relations Review*, vol. 38 (July 1985), pp. 544–57. Also see Harry C. Katz, *Shifting Gears: Changing Labor Relations in the U.S. Automobile Industry* (MIT Press, 1985); and Michael J. Piore and Charles F. Sabel, *The Second Industrial Divide: Possibilities for Prosperity* (Basic Books, 1984).

3. Katz, *Shifting Gears*, pp. 49–72.

4. Wage settlements also reflected the effects of more intense foreign competition. In national contracts after 1980 the International Union, United Automobile, Aerospace and Agricultural Implement Workers of America (UAW) negotiated wage increases with Chrysler, General Motors, and Ford that were smaller than the 3 percent annual improvement factor plus cost-of-living increases common in contracts from 1948 through 1979. These pay concessions were accompanied by the introduction of profit-sharing and job security programs.

5. For example, the automobile industry was the first major American industry to have cost-of-living adjustment escalators in a collective bargaining agreement. The industry also introduced supplementary unemployment benefits and "30 and out" retirement systems. Industrial relations in the auto industry since World War II are described in Katz, *Shifting Gears*.

6. Problems associated with the use of team systems are described in Katz, *Shifting Gears*, pp. 73–104.

companywide collective bargaining agreements negotiated in the fall of 1987 between the UAW and General Motors and Ford.[7] These agreements included guarantees providing that workers can be laid off only because of decreases in auto sales and not because of technological changes, outsourcing, negotiated improvements in productivity, or corporate reorganizations. In return the UAW agreed to the establishment of plant-level committees to examine ways for using team concepts more fully and altering work practices to improve productivity and product quality. These committees are to report back to corporate management regarding jointly accepted changes in work rules. Meanwhile, Chrysler and the UAW have negotiated a number of plant-level agreements that introduce teamwork and decrease the number of job classifications.[8]

While the companies are clearly counting on changes in industrial relations to improve their competitiveness, the economic effects of shop floor practices are not clear. Are numerous job classifications to blame for poor plant performance? Have the recent changes in work rules adopted in some plants produced significant results, and if so, which produced the greatest improvements? In particular, given the focus of management's efforts to introduce work teams, do such systems lead to improved productivity or product quality, and how significant are the improvements?

There is no systematic evidence for evaluating the effects of shop floor industrial relations practices on economic performance.[9] Research

7. These agreements are described in "Summary of Autoworkers' Settlement with Ford Motor Company as Presented to UAW Executive Council Sept. 18," *Daily Labor Report,* September 23, 1987; and "UAW, GM Pact Includes Wage Hike, Job Security Patterned After Ford," *Daily Labor Report,* October 13, 1987.

8. See John Bussey, "UAW Learns 'Innovative' Labor Pacts Can Run Into Rank-and-File Resistance," *Wall Street Journal,* September 5, 1986.

9. Research has looked at how industrial relations performance indicators such as absentee or grievance rates affect economic performance, but these studies have not measured the impact of work rules and work practices on economic performance. See, for example, Harry C. Katz, Thomas A. Kochan, and Kenneth R. Gobeille, "Industrial Relations Performance, Economic Performance and QWL Programs: An Interplant Analysis," *Industrial and Labor Relations Review,* vol. 37 (October 1983), pp. 3–17; John H. Pencavel, "Analysis of an Index of Industrial Morale," *British Journal of Industrial Relations,* vol. 12 (March 1974), pp. 48–55; and Casey Ichniowski, "The Effects of Grievance Activity on Productivity," *Industrial and Labor Relations Review,* vol. 40 (October 1986), pp. 75–89.

has so far been limited by the lack of consistent measures for the practices and the economic performance of a large sample of plants. To remedy this deficiency, we surveyed work practices in the plants of one of the major American auto companies. The survey was carried out with the cooperation of company executives and union officials, but for proprietary reasons we cannot reveal the name of the company. The survey included measures of work rules and the extent of worker participation in shop floor decisions in 1979 and 1986. We used the survey data and corporate measures of product quality and plant productivity to analyze the effects of industrial relations practices on plant economic performance.

The issue that motivated our analysis is the extent and nature of the contribution of industrial relations to the competitive position of American auto companies. To assess that issue, policymakers need to know how American productivity compares with that in foreign auto plants and in plants operating in the United States that are owned by Japanese auto companies (the so-called transplants). Comparative company and country data also are necessary to identify the extent to which differences in industrial relations practices explain productivity differences.

To address these issues, we analyzed data collected by John Krafcik on labor productivity in auto plants in a variety of countries. The data were particularly useful because they compared the productivity in union and nonunion plants in the United States and the performance of the domestically owned plants and the transplants.

Our analysis adds the effects of the industrial relations system to a standard economic production function analysis. We assumed that production is a function of industrial relations practices in the plants as well as of capital and labor. We hypothesized that industrial relations affect economic performance primarily through two channels: discretion exercised by management and the level of cooperation between management and labor.[10] We expected plant economic performance to be better the greater the degree of discretion exercised by management in the allocation and pace of work and the greater the extent of labor-management cooperation.

10. This model is described more fully in Thomas A. Kochan, Harry C. Katz, and Robert B. McKersie, *The Transformation of American Industrial Relations* (Basic Books, 1986), pp. 81–108.

Plant Data

We first analyzed data collected from fifty-three plants of a major American automobile manufacturer. The data were annual measures from each plant for 1979 and 1986 (five of the plants were not operating in 1979). Some plants are in Canada. In 1979 national collective bargaining agreements negotiated between each auto company and the UAW covered all plants in each country. In 1986 the Canadian plants were covered by an agreement between the company and the National Automobile, Aerospace and Agricultural Implement Workers of Canada (CAW); the plants in the United States were covered by an agreement with the UAW.[11] In 1979 and 1986 each plant also had a separate agreement with its local UAW or CAW affiliate. Most of the plants engaged in the final assembly of vehicles, but the sample also included stamping, body fabrication, engine assembly, and auto parts plants. We chose 1979 for the initial observation because this was the last year before this and other American auto companies faced sharp deteriorations in sales (which lasted until 1983). Missing data reduced the sample in some of the analyses.

Measures of the Plant Industrial Relations System

To measure the discretion exercised by management and the level of labor-management cooperation, we surveyed the chief industrial relations manager in each plant.[12] The survey included twenty-three questions concerning managerial discretion and the pace of work—amount of relief and idle time; procedures used to allocate work hours, job

11. The CAW seceded from the UAW in early 1985; however, the secession, per se, did not lead to significant changes in the work practices in Canadian plants. The secession is discussed in Harry C. Katz, "New Developments in Union Structure in the U.S. Auto Industry," in Barbara D. Dennis, ed., *Proceedings of the Thirty-Ninth Annual Meeting of the Industrial Relations Research Association, 1986* (Madison, Wisc.: IRRA, 1987), pp. 112–20.

12. The development of the work practice survey involved extensive consultation with a group of experienced industrial relations managers from the company. We are grateful for their assistance.

transfers, layoffs, and recalls from layoff (including the role of seniority in those policies); number of job classifications for production, non-skilled (nonproduction), or skilled trades workers; and other work organization issues (see questions 1–23 in appendix B).

We scored these questions so that management clearly would prefer a numerically higher score while the work force would prefer a lower one—a higher score indicated either a faster pace of work or greater discretion exercised by management in the allocation of job tasks (and typically a less important role for seniority rights). Thus by aggregating the scores we could infer the extent to which work rules and work practices favored management. It should be kept in mind that the plants varied widely in the degree to which they included team systems, which have few formal job classifications and relatively broad definitions for production jobs.

Our previous field work in auto plants had indicated that labor-management cooperation was greater when workers and union officers participated more extensively in decisions that affected the plant and the production process. In this survey we thus assessed the extent of worker and union participation with twenty-five additional questions on the extent to which the hourly work force or union representatives participated in decisions involving the implementation of new technology on the shop floor, received information on costs and quality in their work area, used statistical quality control techniques, or participated in hiring, overtime scheduling, and training decisions (see questions 24–48 in appendix B).

Corporate records of the number of written grievances per one-hundred hourly workers constituted an additional indicator of labor-management cooperation. We expected that where grievances were fewer, the extent of cooperation would be greater. We also used the absentee rate in each plant as an indicator, expecting high rates to indicate poor worker morale and poor cooperation. The data included the percent of the hourly work force absent for unexcused reasons—what the company called controllable absenteeism—from corporate records. Excused absences included such things as illness or jury duty.

Recently, various theories have proposed that worker effort should be related to the cost of job loss. Where workers have more to lose from being fired for poor performance or by being laid off because of a plant closing, they should shirk less and cooperate more extensively with management.[13] Thus these models have predicted that where the labor market provides more attractive alternatives, on-the-job performance should be poorer. Between 1979 and 1986 this company, like other American auto manufacturers, was closing plants to reduce excess production capacity. The possibility that a plant with poor productivity would be closed was consequently not an idle threat. We therefore tested the efficiency-wage prediction with measures of the attractiveness of the labor market alternatives available to each plant's work force. A wage differential between the plant and the local labor market was calculated by dividing the average hourly wage in each plant by the average wage received by production workers in the plant's labor market area. The unemployment rate in the SMSA in which each plant was located was used as another indicator of the attractiveness of labor market alternatives.[14]

Reducing the Dimensionality of the Responses

Before we could use a regression analysis of the data, we had to resolve the following problem. The number of measures of managerial discretion and labor-management cooperation yielded by the survey was too large to handle within a regression framework. Efforts to identify a meaningful subset of variables were plagued by multicollinearity among many of the most important ones. To solve this problem, we reduced the number of variables by using a confirmatory principal components regression analysis. We divided the forty-eight survey questions into those aimed at capturing the extent of managerial discretion (1–23) and those designed to assess worker and union participation (24–28). We then made a qualitative determination about (that is, we signed) each variable in the two subsets and applied principal components to each

13. Carl Shapiro and Joseph E. Stiglitz, "Equilibrium Unemployment as a Worker Discipline Device," *American Economic Review*, vol. 74 (June 1984), pp. 433–44.

14. The average wage for production workers in the local labor market area was taken from U.S. Bureau of Labor Statistics, *Employment and Earnings*, vol. 27 (May 1980), table A-2, and vol. 34 (May 1987), table A-2. Unemployment rates are from U.S. Department of Labor, *Employment and Training Report of the President* (Government Printing Office, 1980), table D-8; and Bureau of Labor Statistics, *Employment and Earnings*, vol. 34 (May 1987), table A-3.

(appendix A describes the statistical properties of principal components analysis).

The major principal components that were derived from analysis of the responses confirmed our predictions about the way each issue influenced managerial discretion and worker participation. All significant component coefficients were signed in the predicted direction. In this sense the method was confirmatory, not exploratory. Also, the first two components produced by each subset were readily interpretable when we focused on the significant component loadings (those questions with coefficients greater than .45). These loadings divided by the component's eigenvalue were used to weight the standardized variables. The variables were then summed to form indices for each plant that were later used in the regressions.

We retained the first two components generated by the application of principal components to questions 1–23.[15] The signs of the component loadings on the individual questions were in the predicted direction. For example, the percentage of production workers expected to learn different jobs within their work area (question 10) had a positive sign (more favorable to management). Furthermore, these two components appeared to identify two very different types of work-rule policies. The questions with component loadings greater than .45 in the first component (*Teams*) measured rules associated with team work systems. For example, the percent of hourly workers paid for the number of jobs they performed rather than for the specific job on a given day (question 9) was a key indicator of the use of work teams and had a coefficient of .63 in the first management discretion component. Table A-1 in appendix A lists the signs and coefficients on those questions in the two managerial discretion components with coefficients greater than .45. The questions in the second managerial discretion component (*Mandis*) with weights greater than .45, however, concerned the pace of work and aspects of managerial discretion unrelated to teamwork. For example, the per-

15. These two components accounted for 39 percent of the common variation in the questions on management discretion. We experimented with three additional methodologies to analyze management discretion and participation. We applied a principal factor method to questions 1–23, which was able to explain 35 percent of the common variance. We also standardized and summed the responses to the questions, using the predicted sign. Finally, we selected a subset of the responses and used the direct responses. The regressions did not vary with these different methodologies.

centage of workers that have a right to earned idle time (question 3) had a coefficient of .59 in this component.

A principal component analysis was similarly used to generate summary measures of the responses to the questions on worker and union participation.[16] Table A-1 also lists the signs and coefficients on the questions in the two participation components with coefficients greater than .45, using the responses from questions 24 through 48.[17] Questions with weights greater than .45 in the first participation component concern work group activities (*Wrkgrppar*), the extent to which information about costs and product quality was received on a regular basis by a plant's work groups, and the extent of worker involvement in group decisionmaking. For example, the percentage of employees with the responsibility to design, time, and lay out jobs in their work area (question 36) had a weight of .80 in the first participation component.

The questions that weighed heavily in the second participation component (*Techpar*), in contrast, concerned the extent to which workers or union representatives were involved in the implementation of new technology on the shop floor (questions 24–27).

Economic Performance Measures

Our data included various indicators of the economic performance of each plant in 1979 and 1986. We used an annual plant average of a corporate quality index derived from a count of the number of faults and demerits that appeared in inspections of each plant's products.[18]

The company keeps track of the hours of production workers' labor used to produce each vehicle in each plant, but the number of these

16. The first two components explained 45 percent of the common variance in the responses. A principal factor analysis explained a higher level of the common variance (64 percent). We also validated our procedure by standardizing and summing the responses to the twenty-five participation questions, using the predicted sign. Finally, we selected a subset of participation questions and used the direct responses. Again, regardless of the method, the regressions yielded similar results.

17. As with the managerial discretion components, the signs of the significant component coefficients on the individual participation questions were in the expected direction, namely, more worker or union involvement was associated with a higher coefficient.

18. This index can be criticized because it counts all faults equally and does not weight quality problems. It was also not clear that the corporate quality auditors focused on the quality problems perceived by customers.

hours is available for 1979 and 1986 only for final vehicle assembly plants. The company also generates a labor efficiency index for each assembly plant by dividing production worker hours by the standard number of hours each plant is expected to use to assemble the mix of vehicles it produces. The labor standards used in this index are generated by the company's industrial engineers and include considerations of variations in product complexity. We were not certain of the accuracy of the company's correction for product complexity in the computation of standard labor hours, so our analysis used both the raw number of labor hours and the adjusted labor hours.

Our survey of plant work practices recorded the number of first-line supervisors and production workers in each plant. One of the frequent criticisms of management in American auto companies is that there are too many levels of management and too many managers (including supervisors) relative to production workers, especially when compared with Japanese auto companies.[19] We calculated the number of supervisors per production worker in each plant and expected that more efficient plants would have fewer supervisors per worker. There are, however, problems with using this ratio as an indicator of plant performance. Having fewer supervisors per worker does not necessarily indicate lower production costs. It may mean only that supervisory duties have been assigned to other managers or that supervision is being accomplished through other methods. Yet the number of supervisors should shed some light on plant performance, and it had two particular virtues in our study. In contrast to the measures of hours worked, this number was available for nearly all the plants for 1979 and 1986. Furthermore, the number of supervisors per production worker was generated by the survey; it was not part of the company's normal accounting system, from which we acquired our other measures. Our experience with corporate accounting controls suggests that plant managers may sometimes make the numbers look good while not necessarily improving plant performance. An indicator of plant performance that does not come from corporate accounting controls may avoid some of the biases that appear in the other measures of plant performance.

19. This criticism is made in Abernathy, Clark, and Kantrow, *Industrial Renaissance*, for example.

Diversity among Plants

Table 1 reflects the diverse quality of the industrial relations and economic performance of the plants sampled. Despite the common employer and the national collective bargaining agreements, the plants show a wide diversity in labor hours per vehicle, product quality, and grievance and absentee rates. In 1986, for example, grievances per one-hundred workers varied from a low of 1.3 in one plant to 158.5 in another. The absentee rate varied between 1.1 and 4.2 percent of the work force on average throughout the year, the product quality index ranged from 119 to 143, and production worker hours required to assemble a car ranged from 21.2 to 43.1. Even after adjusting the labor hours for labor standards, one plant used 6 percent more hours than the standard to assemble its product mix while another used 32 percent more. The number of supervisors varied from 1.8 per one-hundred production workers in one plant to 20 in another.[20]

The variation among plants in the extent of managerial discretion and worker participation was also extensive. For example, in 1986 the number of job classifications for production workers ranged from 1 to as high as 155. The percentage of the work force that discussed with management how new technology would affect job duties (question 26) ranged from 0 in some plants to 100 percent in others.

What is the source of this variation? Are we observing different but nonetheless equally efficient industrial relations practices among plants? If not, why do different practices persist? Our field observations in these plants suggested that the variation in the amount of discretion exercised by management and the pace of work arises and persists as a consequence of differences in the bargaining power held by workers and their local unions.[21] Workers and the UAW locals generally prefer more limited management discretion in allocating work and regulating its pace. Yet the extent of worker and union bargaining power varies (and has varied)

20. This variation was not narrowed significantly when we controlled for differences in plant type or separated the plants into Canadian and U.S. subsamples. Nor was the variation in labor hours eliminated when plants in start-up phases were excluded. This diversity was similar to that found in Katz, Kochan, and Gobeille, "Industrial Relations Performance."

21. See Katz, *Shifting Gears*, pp. 13–48.

Table 1. Measures of Industrial Relations and Economic Performance, 1979 and 1986

Measure[a]	Mean 1979	Mean 1986	Minimum 1979	Minimum 1986	Maximum 1979	Maximum 1986	Standard deviation 1979	Standard deviation 1986
Absentee rate (percent)	6.01	2.56	2.40	1.10	9.20	4.20	1.62	0.86
Grievance rate (per 100 workers)	62.75	27.37	2.33	1.28	450.20	158.50	77.66	29.92
Labor hours per vehicle	28.82	32.73	20.10	21.20	41.30[b]	43.10[b]	4.88	12.32
Adjusted labor hours	1.15	1.20	0.96	1.06	1.43[b]	1.32[b]	0.15	0.15
Product quality index	128.50	132.89	115.00	119.00	145.00	143.00	6.42	6.03
Supervisors (per 100 production workers)	7.94	7.70	3.0	1.81	24.4	20.26	4.67	4.84

Source: Authors' calculations from sample data.

a. The number of observations for each variable in 1979 are absentee rate (39), grievance rate (45), labor hours (19), adjusted labor hours (19), product quality (40), and supervisors (46). The number of observations in 1986 are absentee rate (35), grievance rate (49), labor hours (19), adjusted labor hours (19), product quality (44), and supervisors (51).

b. Excludes consideration of plants in the midst of product start-up.

substantially among plants. Where workers and union have significant bargaining power they win and defend work practices to their advantage. Management is limited in its ability to shift production out of plants where unions are strong and is sometimes not interested in doing so because of the plants' locations or other economic advantages.

Variations in discretion exercised also derive from recent efforts by American management to change work organization radically by introducing team-oriented work systems. The goal of introducing team systems is to lower costs and increase production flexibility by broadening worker tasks and decentralizing decisionmaking. These systems typically involve fewer job classifications and fewer rules governing worker movements and responsibilities as rulemaking becomes less the province of formal negotiations and more the responsibility of the teams themselves. Yet in some plants the introduction of team systems has been slowed by resistance from workers, unions, or management and by implementation problems.[22] Consequently, the use of the systems varied extensively among plants in the data set.

22. Louise Kertesz, "'Progressive' Work Pacts Split UAW; Lasting Anger Is Feared," *Automotive News*, April 6, 1987; Bussey, "UAW Learns 'Innovative' Labor Pacts Can Run Into Rank-and-File Resistance"; and Katz, *Shifting Gears*, pp. 73–104.

The degree of worker and union cooperation with management also differed substantially. Some plants were characterized by bitter adversarial relations, while in others unions and workers participated extensively in business and production decisions. This variation was due in part to differences in worker and management attitudes in the company and to differences in bargaining leverage that influenced the degree to which either party could enforce its preferences.[23] Workers and local unions varied widely, for instance, in how much they were ideologically opposed to management and to efforts to improve plant performance. Although the UAW and the company management have tried to initiate various worker participation and labor-management programs in the past fifteen years, the spread and depth of these programs continues to vary substantially among plants and to contribute to significant differences in the levels of labor-management cooperation.

Regression Analysis of Company Data

To what extent is the variation in economic performance apparent in table 1 caused by variations in the plants' industrial relations practices? We used the following equation to test our hypotheses:

$$(1)\quad X_{i,t} = K + \alpha_1 \, Teams_{i,t} + \alpha_2 \, Mandis_{i,t} + \alpha_3 \, Wrkgrppar_{i,t} + \alpha_4 \, Techpar_{i,t} + \alpha_5 W_{i,t} + \alpha_6 U_{i,t} + \alpha_7 A_{i,t} + \alpha_8 G_{i,t} + \alpha_9 D_{i,t} + \alpha_{10} S_{i,t} + e_{i,t}.$$

Here, X is a measure of plant i's economic performance in year t (1986 or 1979). X is measured by the quality index, labor hours per vehicle, adjusted labor hours, or the number of supervisors per production worker. *Teams* is the score on the team-related principal component in plant i in year t. *Mandis* is the extent of managerial discretion and the pace of work, *Wrkgrppar* is the extent of worker and union participation in work group decisions, and *Techpar* is the extent of worker and union participation in new technology. W is the ratio of plant i's wage to the average wage in the local labor market, U is the unemployment rate in the local labor market, A is the absentee rate, and G is the grievance

23. See Katz, *Shifting Gears*, pp. 73–104; and Katz, "Policy Debates Over Work Reorganization in North American Unions," in Richard Hyman and Wolfgang Streeck, eds., *New Technology and Industrial Relations* (Basil Blackwell, forthcoming).

Table 2. Logit Estimation Results with Number of Supervisors per Production Worker as Dependent Variable[a]

Variable	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*
Constant	−3.7955[b]	−2.8919[b]	−2.7497[b]	−2.5802[b]	−3.1103[b]
	(0.5647)	(0.1123)	(0.1196)	(0.2407)	(0.3576)
Teams	0.0399	0.1204	. . .	. . .	. . .
	(0.0942)	(0.0741)			
Mandis	−0.3906[b]	−0.3343[b]	. . .	. . .	. . .
	(0.0811)	(0.0709)			
Wrkgrppar	−0.0602	−0.0967	−0.0300	. . .	. . .
	(0.6886)	(0.0717)	(0.0624)		
Techpar	−0.0889	−0.0617	−0.1449[c]	. . .	. . .
	(0.0699)	(0.0566)	(0.0597)		
Absentee	0.0318	. . .	. . .	−0.0043	. . .
	(0.0370)			(0.0360)	
Grievance	−0.0005	. . .	. . .	−0.0003	. . .
	(0.0009)			(0.0010)	
Wagediff	1.2452[c]	. . .	. . .	. . .	0.8035[c]
	(0.4814)				(0.3282)
Unemployment	0.0677	. . .	. . .	. . .	0.0480
	(0.0508)				(0.0400)
Start-up	−0.1887	−0.3539	−0.4330[d]	−0.5995[c]	−0.5331[c]
	(0.2560)	(0.2203)	(0.2347)	(0.2855)	(0.2234)
Assembly[e]	0.5392[b]	0.4408[b]	0.0801	0.0210	0.0092
	(0.1880)	(0.1483)	(0.1412)	(0.1914)	(0.1493)
Body[e]	0.2386	0.4109[b]	0.5487[b]	0.4765[c]	0.3773[c]
	(0.2061)	(0.1543)	(0.1678)	(0.2249)	(0.1784)
$\bar{R}^2$	.39	.34	.19	.11	.19
Number	72	96	96	72	96

Source: Authors' calculations.
a. Standard errors in parentheses.
b. Statistically significant at the 0.01 level, two-tailed test.
c. Statistically significant at the 0.05 level, two-tailed test.
d. Statistically significant at the 0.10 level, two-tailed test.
e. The excluded category of plants was engine and other parts plants.

rate. D represents dummy variables for the type of plant,[24] and S is a dummy variable of value 1 if the plant is in the midst of starting up production of a new product in year t.

Regression Results

Tables 2 through 5 report the results of the regression estimates of equation 1 with various measures of plant economic performance as

24. Plant types are final assembly (*Assembly*), stamping and fabrication (*Body*), and engine and other (various parts plants).

Table 3. Weighted Least Squares Estimation Results with Labor Hours as Dependent Variable[a]

Variable	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*
Constant	33.4939[b]	33.4335[b]	28.5969[b]	28.6001[b]	17.8518[b]
	(6.3870)	(3.3482)	(1.4986)	(2.0636)	(5.9878)
Teams	4.4738[c]	6.6067[b]	. . .	. . .	. . .
	(1.7779)	(2.0511)			
Mandis	−4.9085[c]	−3.8741	. . .	. . .	. . .
	(1.8949)	(3.2326)			
Wrkgrppar	−3.2317	−4.9735[c]	0.5640	. . .	. . .
	(1.9116)	(2.2594)	(1.4277)		
Techpar	−1.1206	−1.3167	−0.5996	. . .	. . .
	(0.8136)	(1.2668)	(1.4202)		
Absentee	−0.0154	. . .	. . .	−0.0740	. . .
	(0.5543)			(0.4876)	
Grievance	0.0059	. . .	. . .	0.0076	. . .
	(0.0104)			(0.0107)	
Wagediff	5.4869	. . .	. . .	. . .	4.0431
	(5.0891)				(7.5013)
Unemployment	−0.2362	. . .	. . .	. . .	1.6757[c]
	(0.7135)				(0.8198)
Start-up	7.2883[c]	10.6669[c]	18.9771[c]	9.1717[b]	16.1904[b]
	(2.9542)	(4.5607)	(3.9695)	(2.6492)	(4.0549)
$\bar{R}^2$	.49	.54	.41	.27	.45
Number	28	33	33	28	33

Source: Authors' calculations.
a. Standard errors in parentheses.
b. Statistically significant at the 0.01 level, two-tailed test.
c. Statistically significant at the 0.05 level, two-tailed test.

the dependent variables. Equations for tables 3 to 5, with labor hours, adjusted labor hours, and product quality, were estimated using weighted least squares, with plant employment used as the weights to avoid heteroskedastic errors.

Since the level of supervision is measured as a percentage of the work force, with a restricted range between 0 and 1, ordinary least squares is an inefficient and potentially biased estimator when the ratio of supervisors to production workers is the dependent variable. Instead, to estimate the equations listed in table 2, we used a logit for grouped data, applying weighted least squares to correct for heteroskedasticity.[25] The level of supervision was measured as the ratio of first-line supervisors to

25. See G. S. Maddala, *Limited-Dependent and Qualitative Variables in Econometrics* (Cambridge University Press, 1983), pp. 29–30; and Marc Nerlove and S. J. Press, *Univariate and Multivariate Log-Linear and Logistic Models* (Santa Monica, Calif.: Rand Corporation, 1973).

Table 4. Weighted Least Squares Estimation Results with Adjusted Labor Hours as Dependent Variable[a]

Variable	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*
Constant	0.9067[b]	1.2586[b]	1.1350[b]	1.0510[b]	1.1634[b]
	(0.1581)	(0.0542)	(0.0229)	(0.0575)	(0.1030)
Teams	0.0073	0.0437	...	...	...
	(0.0440)	(0.0332)			
Mandis	−0.1619[b]	−0.1262[c]	...	...	...
	(0.0469)	(0.0523)			
Wrkgrppar	0.0101	−0.0509	−0.0327	...	...
	(0.0473)	(0.0366)	(0.0218)		
Techpar	−0.0510[c]	−0.0462[c]	−0.0536[c]	...	...
	(0.0201)	(0.0205)	(0.0217)		
Absentee	0.0300[c]	...	...	0.0147	...
	(0.0137)			(0.0136)	
Grievance	0.0001	...	...	0.0003	...
	(0.0003)			(0.0003)	
Wagediff	0.1444	...	...	...	−0.1178
	(0.1260)				(0.1290)
Unemployment	0.0360[d]	...	...	...	0.0017
	(0.0177)				(0.0141)
Start-up	0.3901[b]	0.2499[b]	0.2696[b]	0.3264[b]	0.2169[b]
	(0.0731)	(0.0738)	(0.0606)	(0.0739)	(0.0697)
$\bar{R}^2$	.67	.46	.36	.39	.27
Number	28	33	33	28	33

Source: Authors' calculations.
a. Standard errors in parentheses.
b. Statistically significant at the 0.01 level, two-tailed test.
c. Statistically significant at the 0.05 level, two-tailed test.
d. Statistically significant at the 0.10 level, two-tailed test.

production workers in a plant. Using the ratio, the logit was written as the log-odds ratio of observing a supervisor on the shop floor.[26]

In the face of the potential biases resulting from estimation of this reduced-form equation, tables 2 through 5 show the estimation results with various combinations of included independent variables. In column 3 of tables 2 through 5 we report the estimation results with the

26. The log odd is linearly conditioned on a set of explanatory variables, where $\ln (p_i/1 - p_i) = B'X + e$. The p_i's are the proportion of supervisors in relation to all production workers, and are assumed to be mutually independent and drawn from a random binomial population. Since the error term is heteroskedastic, weighted least squares is the appropriate estimating procedure. The weight is constructed as follows: $w_i = n_i p_i (1 - p_i)$, where w_i is the weight for the ith observation, n_i is the number of workers and supervisors in the ith plant, and p_i is the proportion of supervisors in the ith plant. This weighted least squares estimator is known as the minimum logit chi-square method.

Table 5. Weighted Least Squares Estimation Results with Quality as Dependent Variable[a]

Variable	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*
Constant	137.0787	138.2750[b]	137.7389[b]	139.6607[b]	131.3656[b]
	(5.7065)	(1.4398)	(1.3790)	(2.0753)	(3.9616)
Teams	0.2744	0.5397	. . .	. . .	. . .
	(0.9306)	(0.7881)			
Mandis	1.4827	0.8870	. . .	. . .	. . .
	(0.9982)	(0.9304)			
Wrkgrppar	−0.6508	0.2884	0.7040	. . .	. . .
	(0.8307)	(0.7344)	(0.5686)		
Techpar	0.3209	0.9945	1.1066[c]	. . .	. . .
	(0.7335)	(0.6536)	(0.6278)		
Absentee	−0.7181[c]	. . .	. . .	−0.6926[d]	. . .
	(0.3823)			(0.3116)	
Grievance	−0.0072	. . .	. . .	−0.0074	. . .
	(0.0096)			(0.0092)	
Wagediff	0.2889	. . .	. . .	. . .	2.6967
	(4.8898)				(3.8247)
Unemployment	0.4671	. . .	. . .	. . .	0.6321
	(0.5237)				(0.4238)
Start-up	−5.6838[d]	−5.9794[b]	−5.0719[b]	−4.9750[d]	−4.4039[d]
	(2.4138)	(2.1707)	(2.0312)	(2.1019)	(1.9678)
Assembly[e]	−9.2402[b]	−10.3455[b]	−9.4156[b]	−8.1271[b]	−7.9258[b]
	(2.1403)	(1.9058)	(1.5466)	(1.6772)	(1.6998)
Body[e]	−1.9617	−3.5087[c]	−3.7294[c]	−2.2547	−2.7855[c]
	(2.2507)	(2.0008)	(1.9745)	(2.0910)	(2.0158)
$\bar{R}^2$	.37	.40	.40	.37	.39
Number	70	79	79	70	79

Source: Authors' calculations.
a. Standard errors in parentheses.
b. Statistically significant at the 0.01 level, two-tailed test.
c. Statistically significant at the 0.05 level, two-tailed test.
d. Statistically significant at the 0.10 level, two-tailed test.
e. The excluded category of plants was engine and other parts plants.

participation indices as the only industrial relations measures in the equation.[27]

We focus here on the results where the number of supervisors and labor hours are used as dependent variables (tables 2 and 3), since the economic significance of the coefficient estimates in these equations is easier to interpret. More extensive use of teams (controlling for the level

27. We do this because the principal component, *Wrkgrppar*, is highly correlated with the principal component *Teams* ($p = 0.70$), and hence the influence of *Wrkgrppar* may be confounded with the influence of *Teams* in the other estimated equations.

of worker participation), as indicated by a higher score for *Teams,* caused more supervisors and labor hours. In table 3, equation 2, the association between *Teams* and labor hours is statistically significant at the 1 percent level.

Furthermore, the negative effects on productivity from the use of teams were sizable. The coefficients in equation 2 in tables 2 and 3 imply that a one-standard-deviation increase in *Teams* leads to 3.0 more supervisors per one-hundred workers in the plant and 7 hours and 28 minutes more labor time required to assemble each car.

The negative effect of the use of team systems on plant productivity did not appear to derive from their expanded use in plants that had low productivity due to some other (unmeasured) factors. Plants with relatively low labor hours in 1979 (or fewer supervisors) were slightly more likely to experience increases in the use of teams between 1979 and 1986. This is indicated by the fact that the simple Pearson correlation coefficient between the change in *Teams* from 1979 to 1986 with labor hours in 1979 is −.16. The simple correlation between the change in *Teams* from 1979 and 1986 and the number of supervisors in 1979 is −.19.[28] While neither correlation was statistically significant at conventional levels, the lack of significant positive correlations allowed us to reject the argument that teams were introduced more frequently in plants that were already performing poorly.

Greater managerial discretion in interpreting work rules and a faster pace of work, as indicated by a higher score in *Mandis,* caused fewer supervisors and labor hours. In table 2, equation 2, the association between *Mandis* and the number of supervisors is statistically significant at the 1 percent level. The magnitudes of the effects of greater managerial discretion also are sizable. The coefficients in equation 2 in tables 2 and 3 imply that a one-standard-deviation increase in *Mandis* caused 8.5 fewer supervisors per one-hundred workers and 1 hour and 49 minutes less to assemble a car.

More extensive worker and union participation in decisionmaking (controlling for the extent of managerial discretion) also leads to fewer supervisors and labor hours. In equation 2, table 3, the association between *Wrkgrppar* and labor hours is statistically significant at the 5 percent level. However, the other associations between the participation

28. The number of observations in these correlations was nineteen.

indices and the number of supervisors and labor hours in equation 2, tables 2 and 3, are not statistically significant.

Although the statistical significance of the participation indices were weak, the estimated size of the effects suggested that these variables were important. The coefficients in equation 2, tables 2 and 3, imply that a one-standard-deviation increase in *Wrkgrppar* leads to 2.4 fewer supervisors per one-hundred workers and 4 hours and 41 minutes less time to assemble a car. A one-standard-deviation increase in *Techpar* causes 1.5 fewer supervisors and 1 hour and 25 minutes less time.

In the equations reported in tables 4 and 5 the same patterns hold. More extensive use of teams generally caused higher adjusted labor hours and lower quality across the estimated equations, while greater managerial discretion and a faster work pace (higher values of *Mandis*) and more participation (higher values of *Wrkgrppar* and *Techpar*) generally caused fewer adjusted labor hours and higher quality. Not many of the coefficients on the principal components in the estimated equations reported in tables 4 and 5, however, were statistically significant at even the 10 percent level.

Measures of the external labor market (the unemployment rate and the wage differential between the plant and the local labor market) did not affect plant economic performance in the hypothesized manner. In equations 1 and 5 in table 2, in fact, a higher plant wage relative to the wage in the local labor market led to more supervisors, not fewer as predicted by a "shirking" hypothesis of efficiency-wage theories, and the coefficient on the wage differential variable was statistically significant at the 5 percent level. In equation 5, table 3, a higher unemployment rate led to more labor hours, again a result opposite to that predicted by the shirking hypothesis, and the coefficient was statistically significant at the 5 percent level.

The equations reported in tables 2 through 5 provide little evidence that higher grievance rates led to lower plant productivity. Higher absentee rates were associated with lower product quality at the 10 percent and 5 percent levels of statistical significance in equations 1 and 4, table 5, and higher absentee rates were associated (at the 5 percent level) with more adjusted labor hours in equation 1, table 4.

The principal components analysis of the management discretion and worker participation questions may have missed or blurred the importance of particular work practices. As an alternative to the principal components analysis, we chose those survey questions (numbers 1, 10, 17, 19, 21, 25, 31, 43, 48) that we thought concerned the most critical work practices, based on our knowledge of the auto production process, and entered the survey responses to them directly into equation 1 in place of the principal component indices. The results were consistent with the ones reported above. Responses indicating greater managerial discretion and faster work pace positively affected productivity and product quality. Responses indicating greater use of teams had either a negative effect or no effect on labor productivity and product quality. Greater worker participation, as reflected in higher scores for these responses, caused higher productivity (fewer labor hours) and better product quality. The number of production-worker job classifications, however, consistently had no statistically significant effect on either labor hours or product quality.[29] This result was particularly striking in the face of the emphasis American management has put on reducing the number of these job classifications.

To control for the influence that unmeasured plant-specific effects may have exerted in equation 1, we estimated an equation using a measure of change in plant-level economic performance between 1979 and 1986 as the dependent variable and measures of change in the industrial relations system as the independent variables. This was equivalent to estimating a fixed-effects model and assuming plant fixed effects were identical in 1979 and 1986. These equations were estimated with the change in either product quality or the number of supervisors per production worker as the dependent variable; our sample was too small to estimate such an equation with labor hours or adjusted labor hours as the dependent variable.[30] In the estimated change equations none of the coefficients on the independent variables was statistically significant at even the 10 percent level.[31]

29. The number of craft worker job classifications did lead to fewer labor hours and fewer supervisors. The effect was statistically significant at the 1 percent level in the estimated equations with individual question responses entered as independent variables. It should be remembered that in the principal components analysis, the number of production-worker job classifications loaded strongly on the *Teams* component, while the number of craft-worker job classifications loaded strongly on the *Mandis* component.

30. In 1979 and 1986 a number of assembly plants were closed for model changeover, which contributed to the small sample for assembly plants.

31. Equations with the change in product quality and change in the number of supervisors have thirty-seven and forty-six observations, respectively. The estimation results are available from the authors upon request.

Effects of Work Practices on Productivity among Firms

The foregoing discussion has analyzed the contribution of industrial relations practices to the productivity among the plants of one American auto company. The data suggested that differences in such practices contribute significantly to differences in plant productivity. The data also showed that team systems of work organization in this firm did not yield positive results. We now turn to a data set that allows us to compare the labor productivity in this firm with that in a broad sample of U.S. and foreign auto plants.

These comparative data were collected by John Krafcik as part of the International Motor Vehicle program at the Massachusetts Institute of Technology.[32] We first focus on what Krafcik's comparative data suggest regarding the extent of company and country auto productivity differentials and then discuss what these data imply for the role of industrial relations.

Krafcik calculated the labor productivity in twenty-nine assembly plants owned by a variety of companies and operating in a number of countries. He calculated the number of hours of hourly and salaried labor used to accomplish a group of designated standard activities on a product standardized by size, option content, and weld requirements. The number of workers involved in assembly operations in each plant and the number of vehicles assembled were counted and then standardized across plants by adjusting for the complexity of the product and excluding labor hours used to perform nonstandard final assembly tasks. The exclusion essentially adjusted for differences in corporate structure and the degree of vertical integration in corporate assembly and related operations. Making these adjustments was difficult and required knowledge of plant operations acquired through visits and through familiarity with the automobile assembly process.

Krafcik's calculations contrast with economists' traditional efforts to derive marginal production costs from a production function analysis.

32. See John F. Krafcik, "High Performance Manufacturing: An International Study of Auto Assembly Practice," working paper (International Motor Vehicle program, Massachusetts Institute of Technology, January 1988). We are grateful to Krafcik and James Womack for allowing access to the data. Original access to the plants in this data set was provided with the condition that specific plants and companies not be identified. Our analysis benefits from the fact that we have visited some of these plants and observed their industrial relations practices.

In his procedure there are no controls for such things as differences in the quantity or quality of the capital stock used in assembly plants or differences in product design that might influence the ease with which workers can assemble the autos (what is referred to in the industry as product manufacturability). Furthermore, his productivity measures focused on the number of labor hours used to assemble a vehicle and ignored differences in rates of pay, capital costs, and the costs of other inputs.

Krafcik derived labor productivity figures for five plants in Japan, thirteen in North America, and eleven in Europe. Of the North American plants, three were Japanese transplants and some were in Canada. Krafcik found that Japan averaged 20.3 labor hours per vehicle, North America 24.4, and Europe 33.9. The productivity differential of 20 percent between U.S. and Japanese assembly plants was on the same scale as the 36 percent differential Clifford Winston derived from his econometric estimation of automobile industry cost functions. Earlier analyses had estimated a more substantial differential.[33]

Do differences in industrial relations practices help explain why Japanese auto plants have higher productivity? Japanese practices do differ significantly from those traditional in American and European manufacturing.[34] Japanese plants use few job classifications, encourage worker participation in production decisions on the shop floor, and link pay to workers' and firms' performance. Our field observations in Japanese auto plants concluded that these practices facilitated the operation of just-in-time inventory systems and the prevailing decentralized mode of decisionmaking. The plants seemed to link informal and decentralized industrial relations and work practices to highly effective manufacturing practices.

Yet the lack of detailed data on these industrial relations practices

33. See Winston and associates, *Blind Intersection,* p. 16. Winston's estimate is lower, for example, than that found in Abernathy, Clark, and Kantrow, *Industrial Renaissance,* p. 61. Krafcik's data also revealed substantial diversity in labor productivity among companies as well as among plants within particular companies in a country. For example, two domestically owned North American assembly plants had productivity figures below the Japanese average. Labor hours in the six North American assembly plants of one company ranged from 26.1 to 35.7 hours per vehicle in Krafcik's data set.

34. See Yasuhiro Monden, *Toyota Production System: Practical Approach to Production Management* (Norcross, Ga.: Industrial Engineering and Management Press, 1983); and Michael A. Cusumano, *The Japanese Automobile Industry: Technology and Management at Nissan and Toyota* (Harvard University Press, 1985).

makes it impossible to know if or to what degree the higher Japanese productivity suggested in Krafcik's data is caused by greater managerial discretion (equivalent in our American company data set to higher scores of *Mandis*), more extensive use of team systems (equivalent to higher scores of *Teams*), greater worker and union participation in decisionmaking (equivalent to higher scores of *Wrkgrppar* and *Techpar*), or some other work practices. It is noteworthy, nonetheless, that team systems appear to be an integral part of the Japanese auto production system.

In the American company there was no positive advantage to using team systems, and in some cases the systems provided no increase in worker participation in shop floor decisionmaking. Is this a problem common to all U.S. auto plants? Krafcik's data set suggested that Japanese transplants may have avoided some of the problems plaguing the American auto company we analyzed. The three transplants in his data set showed significantly better labor productivity than the average American plants. And in an earlier paper he reported that as of the summer of 1986 the New United Motor Manufacturing (NUMMI) assembly plant jointly owned by General Motors and Toyota in Fremont, California, used only 8.2 percent more labor hours per vehicle than did its extremely high-performing sister plant (Takaoka) in Japan.[35]

Do industrial relations practices contribute to the superior performance of the transplants? The transplants do use manufacturing and industrial relations practices that are similar, although not identical, to Japanese practices. The NUMMI plant, for example, uses work teams and has only four job classifications (one for production workers and three for skilled trades). Unlike the two other transplants, the plant is unionized (UAW). Unionization per se, however, does not appear critical. Krafcik's data showed that NUMMI's labor productivity was nearly identical to that of one of the unorganized transplants and 18.1 percent higher than that of the other. It is difficult to draw strong conclusions with such limited data, but NUMMI's experience suggests that it is possible to operate with unionized labor and come very close to Japanese levels of productivity.[36]

35. Krafcik, "High Performance Manufacturing," p. 17; and Krafcik, "Learning from NUMMI," working paper (Massachusetts Institute of Technology, International Motor Vehicle program, September 1986).

36. Since all U.S. assembly plants of General Motors, Ford, and Chrysler are unionized, it is not possible to compare union and nonunion experiences.

Like their sister plants in Japan, the transplants do seem to have found a way to link team systems and informal industrial relations to decentralized and effective manufacturing practices.[37] Krafcik's analysis of his data lends further support to this view: he found that an index of management policy measuring the use of team systems, dedicated repair space, visual control of the production process, and the absentee rate was a strong predictor of productivity and product quality.[38] Nonetheless, for the transplants as well as the Japanese plants, we do not yet have sufficient data to assess the contribution of specific shop floor practices as we did for the American auto company we analyzed.

Summary and Policy Implications

Much of the debate and conflict in American industrial relations in recent years has focused on changes in shop floor work practices. Confronted with intensified international competition, management and labor are searching for ways to lower costs and improve quality. Management continues to press for fewer job classifications, higher work loads, and greater discretion in allocating human resources. Unions sometimes oppose these changes, in part because they remain unconvinced that the changes will lead to improved competitiveness and employment security.

Our analysis suggests that it is important to distinguish between various types of work practices. Some practices influence the pace of work and the degree of discretion exercised by management, while others affect the degree of worker and union participation in shop floor decisions. Our analysis of plant-level data from one American company indicates that where there is less relief and idle time and more managerial discretion in the allocation of overtime, layoffs, and job transfers, labor hours and the number of supervisors per production worker are significantly decreased and product quality is improved.

37. For a similar argument that effective integration of Japanese manufacturing practices with teamwork and worker participation in decisionmaking leads to the high performance of the transplants, see Haruo Shimada and John Paul MacDuffie, "Industrial Relations and Humanware: Japanese Investments in Auto Manufacturing in the United States," working paper 1855-87 (Massachusetts Institute of Technology, Sloan School of Management, December 1986).

38. Krafcik, "High Performance Manufacturing," p. 9.

Yet, greater use of team systems in this company has led to substantially higher labor hours and more supervisors. We found no evidence that plants with fewer production-worker job classifications performed better. The absence of positive results from adopting work teams and reducing production-worker job classifications was particularly striking in light of the fact that a number of auto and other companies have recently invested so much effort in shifting to these kinds of work practices.

Although the use of work teams does not per se appear to increase productivity, our data do suggest that increased worker and union participation in work group and technology-related decisions has decreased production costs and improved product quality. The statistical associations between our measures of participation and plant economic performance, however, remain weak.

It is possible, of course, that the negative effects of work teams on plant productivity in the company we analyzed resulted from problems associated with introducing the system and that teams may yet help improve productivity (they were first introduced into this company in the late 1970s). Furthermore, teams do represent a significant departure from traditional American industrial relations practices, and their successful implementation may require other changes in managerial practice and worker attitudes that take time to accomplish. Yet it is surprising that even by 1986 there was no evidence of a positive return from the use of teams.

Data collected by John Krafcik have showed that the labor productivity of Japanese plants and Japanese-owned transplants operating in the United States is high relative to that of the average American plant. Our field observations of plants in Japan and of transplants suggest that reliance on teams and the use of fewer job classifications contributed to the high performance of these plants. The Japanese auto companies benefit from team systems because the systems are linked to decentralized manufacturing practices, a linkage missing in the American auto company.

American auto companies and the UAW are counting on changes in work rules spurred by expanded employment security to improve competitiveness. If auto company managements use any new cooperative spirit on the part of the work force to introduce team work systems more rapidly, our data suggest the teams will be counterproductive unless they promote increases in worker and union participation in shop floor decisions and unless they are linked to revised manufacturing practices. Furthermore, the data suggest that plant performance also can be improved by changes in work rules that increase the pace of work and allow greater managerial discretion in assigning work. Workers often find such increased managerial power distasteful, and it is possible that the new employment security programs at Ford and General Motors will reduce worker incentives to make such work rule changes. The new employment security programs at Ford and General Motors will prove extremely costly if auto workers come to believe that these programs insulate them from the need to improve plant productivity and to modify industrial relations. What appears necessary are integrated changes in work and manufacturing practices that increase worker participation and lower production costs.

Krafcik's data suggest that the interests of the American consumer can be promoted by encouraging the expanded operation of Japanese-owned transplants. These plants have high productivity even when, as in the case of NUMMI, they operate with a unionized work force.

In the face of the dramatic depreciation of the dollar against the yen in the past two years, the transplants likely will become important competitors with American auto companies. Such a challenge will make it even more important to understand which industrial relations practices contribute to the high productivity of Japanese transplants and how much they contribute. We also need to understand why the American auto company we analyzed received so little benefit from its expansion of team systems and reductions in job classifications. The need for more research is obvious.

Appendix A: Statistical Properties of Principal Components Analysis

Principal components analysis reduces the dimensionality of a data set of a large number of interrelated variables through the construction of linear combinations of the original variables that account for the maximum amount of total variation.[39] This reduction is accomplished

39. Principal components analysis is described in Harold Hotelling, "Analysis of a Complex of Variables into Principal Components," *Journal of Educational Psychology*, vol. 24 (September 1933), pp. 417–41; vol. 24 (October 1933), pp. 498–520; and I. T. Jollife, *Principal Component Analysis* (Springer-Verlag, 1986).

Table A-1. Principal Component Coefficients

Discretion and work pace			*Participation*		
Question	*Teams*	*Mandis*	*Question*	*Wrkgrppar*	*Techpar*
1	...	−.49	24	+.52	+.56
2	−.54	...	25	...	+.67
3	...	−.59	26	...	+.66
4	...	−.49	27	...	+.59
5	...	−.57	28	+.52	...
6	...	+.51	29	+.60	...
7	...	−.51	30	...	...
8	...	−.61	31	+.73	...
9	+.63	...	32	+.73	...
10	+.74	...	33	+.70	...
11	+.72	...	34	+.67	...
12	+.51	...	35	+.77	...
13	+.51	...	36	+.80	...
14	+.68	...	37	+.50	...
15	+.55	...	38	...	...
16	+.62	...	39	...	...
17	+.67	...	40	+.47	...
18	+.62	...	41	+.63	...
19	+.53	...	42	+.55	...
20	+.65	...	43	+.73	...
21	−.51	...	44	+.59	...
22	−.49	−.50	45	+.51	...
23	...	−.65	46	+.76	...
			47	+.82	...
			48	+.77	...

Source: Authors' calculations from sample data.

by transforming to a new set of uncorrelated variables the principal components, which retain the variations present in the original data. The principal components are ordered so that the first few retain most of the variation present in all the original variables. Specifically, the first principal component is the unique linear combination of the original variables determined by a function maximizing the total amount of variance accounted for by one component; the second component, uncorrelated and orthogonal to the first, captures the maximum of the residual variance; and so on, until all the original variance is explained. The properties of orthogonality and maximization of variance uniquely define principal components.[40] The sum of the variances of all the principal components is equal to the sum of the variances of the original

40. See John E. Overall and C. James Klett, *Applied Multivariate Analysis* (McGraw-Hill, 1972), p. 57.

variables. An assumption of normality is not made in order to use principal components. Since it is deviations from the norm that are of interest, the number of variables is reduced by discarding the linear combinations (components) that have small variances and no theoretical significance and then studying only those with large variances.[41] Computation of principal components reduces to the solution of an eigenvalue-eigenvector problem for a positive semidefinite symmetric matrix. Table A-1 lists the sign and coefficients on the questions in the managerial discretion and participation components with coefficients greater than .45.

Appendix B: Work Practice Survey

DISCRETION AND WORK PACE QUESTIONS

1. What percentage of hourly employees receives more relief time by local agreement or practice than they are entitled to by the national agreement?
2. What percentage of hourly employees receives tag relief?
3. What percentage of hourly employees has a *right* to earned idle time?
4. What percentage of hourly employees *regularly qualifies* for earned idle time?
5. What percentage of the time is overtime allocated by a low-man overtime concept?
6. What percentage of the time is overtime allocated by a spread-in-hours overtime concept?
7. During a permanent layoff, is it possible under the terms of your seniority agreement for more senior *production* workers to be on layoff by their own choice, while younger workers stay in the plant?
8. How often are hourly employees allowed by your local agreement to make an intraplant transfer move each 12 months?
9. What percentage of production workers is paid for the number of jobs they are able to perform rather than for the specific job performed on a given day?
10. What percentage of production workers in a given work area is expected to learn the different jobs within their work area?

41. T. W. Anderson, *An Introduction to Multivariate Statistical Analysis*, 2d ed. (John Wiley, 1984), p. 451.

11. What percentage of production workers is required to rotate across jobs in their work area sufficiently to maintain proficiency in those jobs?
12. What percentage of production workers on occasion sets up and adjusts their machines?
13. What percentage of production workers on occasion performs minor maintenance?
14. What percentage of production workers on occasion inspects their own work?
15. What percentage of production workers on occasion performs any necessary "repair" work on their own work?
16. What percentage of production workers on occasion performs any necessary repair work on work done by others?
17. What percentage of production workers on occasion inspects the work of others?
18. What percentage of production workers on occasion performs their own housekeeping?
19. What percentage of skilled, maintenance, or tooling workers regularly performs incidental tasks of other skilled trades (we mean by incidental tasks such things as the disconnection of hydraulic hoses, bracket making, or the removal of guards)?
20. When performing an incidental task as described in question 19, what percentage of skilled, maintenance, or tooling workers can do *all that is necessary* to complete the job without calling in other trades, subject to training and safety requirements?
21. How many separate job classifications are there for production or assembly workers? (Utility should be counted as one classification.)
22. How many separate job classifications are there for nonskilled employees, other than production or assembly, such as material, unskilled maintenance, or inspectors?
23. How many separate job classifications are there for skilled, tooling, or maintenance workers?

PARTICIPATION QUESTIONS

24. Of those workers directly affected by new technology (new machines or processes), typically what percentage of those workers or their

elected representatives discusses *the new technology* with management *before the final design specifications* are decided?

25. Of those workers directly affected by new technology (new machines or processes), typically what percentage of those workers or their elected representatives discusses with management the way *jobs* or *duties* will be restructured by the new technology *before the final decisions* are made?
26. Of those workers directly affected by new technology (new machines or processes), typically what percentage of those workers or their elected representatives discusses the *impact* on new jobs or employment levels *after new technology has been selected or introduced?*
27. Of those workers directly affected by new technology (new machines or processes), typically what percentage of those workers or their elected representatives is involved in planning and coordinating *training* for employees *after* new technology has been introduced?
28. What percentage of employees in a given work area certifies when their peers master new skill levels or job requirements?
29. In what percentage of cases are work assignments within a given work area regularly made by employees (as a group) rather than by a supervisor?
30. What percentage of employees in a given work area regularly participates in training new workers in their area?
31. What percentage of employees in a given work area regularly maintains written records on quality?
32. What percentage of employees in a given work area regularly maintains written records on costs?
33. What percentage of employees in a given work area regularly maintains written records on productivity?
34. What percentage of employees in a given work area regularly maintains written records on scrap?
35. What percentage of employees in a given work area is involved in setting individual work loads?
36. What percentage of employees has the responsibility to design, time, and lay out jobs in their work area?
37. What percentage of employees has the right to stop the line or production process to correct a problem?

38. How many company-paid full-time union representatives function in your plant (*include* shop and other union committeemen, benefit plant reps., health and safety reps., EAP reps., attendance coordinators and counselors, training coordinators, QWL coordinators, and other full-time reps.)?
39. How many salaried employees are there in the plant whose *primary* job is to interface on a *regular basis* with union reps. (include salaried employees such as labor reps., health and safety reps., benefit plan administrators, training coordinators, QWL coordinators, and others)?
40. How many hours of formal orientation typically are provided *new* production employees?
41. How many hours of formal training *other than orientation* are provided on average to *new* production employees?
42. How many hours of formal training *other than orientation but including joint training activities* are provided to hourly employees *already working* in the plant on average *annually*?
43. What percentage of hourly employees meets on a regular basis in small groups to discuss production or quality problems?
44. What percentage of hourly employees tracks or is given statistical information on *their work group's* quality or productivity performance?
45. What percentage of hourly employees' attitudes is regularly assessed through surveys or is discussed regularly in group meetings?
46. What percentage of hourly employees receives formal training in group problem solving, decisionmaking, and communications?
47. What percentage of hourly employees receives formal training in statistical process control techniques?
48. What percentage of hourly employees regularly *utilizes* statistical process control techniques?

Comments and Discussion

Edward Lazear: Most of the discussion of productivity in recent years has been of the popular variety, with evidence consisting more of rumors than of facts. Harry Katz, Thomas Kochan, and Jeffrey Keefe provide the first hard empirical evidence on the effects of various industrial relations approaches on productivity. For this reason, the paper is both interesting and important. But like Marc Antony, a discussant's job is to bury the authors, not to praise them, and there are some ways the paper might be improved.

I will comment on problems of structure, of measurement, and of interpretation, and on some more technical disagreements. First, the entire structure of the authors' approach seems unusual. The authors think in terms of a tension between workers and management over work rules and other issues. For example, they write, "We scored the work rules question so that management would clearly prefer a high response, while the work force would prefer a low response. A high response to work rules questions indicated either a faster pace of work or greater discretion exercised by management in the allocation of job tasks." At first blush, it certainly seems reasonable that workers and management would have differences of opinion about how hard a worker should work. But virtually all economic analyses that look at the interaction between workers and firms conclude that the firm, even in a monopsonistic setting, maximizes workers' welfare for a given level of profit. Stated alternatively, profit maximization is consistent with making the worker as well off as possible per dollar of profit. What is not clear from reading the paper is that dollars are not allowed to adjust. That is, the authors implicitly assume that management actions are taken without any adjustment in the price paid to labor. This assumption is problematic because the heart of the issue is the effect of work rules on cost. Cost can go up either because hours used per automobile go up or because hours per automobile stay constant but the price paid to labor goes up. Workers who are forced to work in a less attractive environment must be compensated through higher wages. That is true even in a union setting, and for this reason I believe the methodology is somewhat flawed. This is more than a mere measurement problem. By not modeling cost and productivity explicitly, the authors have tricked themselves into thinking that their dependent variables are more closely related to the relevant concept than they are. It is not sensible to talk about whether one approach to industrial relations is better than another without looking at the effects of that approach, effects not only on factor utilization but also on the prices paid for those factors. Once one does that, any tension between management and labor on that particular score is less viable.

The same point is more concretely relevant in assessing their results. The authors find that greater managerial discretion implies higher productivity when measured through fewer hours. That may well be true, but the question is whether labor hours by themselves are relevant. They are certainly of interest, but they are not the whole story. If greater managerial discretion means more output per hour, but also means that management must increase compensation to labor by more than the savings in terms of labor hours, then one would hardly argue that giving greater managerial discretion is an appropriate tool for improving the American automobile industry's standing vis-à-vis the rest of the world.

Let me turn to a somewhat different, but also structural, problem. The authors are aware that there is some potential for simultaneity bias in almost all empirical analyses. However, awareness is not sufficient; bias must be addressed in a much more careful fashion. The reason is as follows: most of the data they have are cross-sectional. Although they have a panel data set, little is gained by using the panel aspects, and one must ask, then, why some plants use one approach to industrial relations while others use another. Put more concretely, the authors find that performance measures vary greatly by plant. Surely the company must be aware of some of these differences, or else one would have to claim that it is totally naive about the effect of industrial relations policy on performance or that the variations are spurious. One can interpret differences across plants and performance in two ways. One is that the firm has installed industrial relations practice in a random way and the differences reflect those practices. The other is that all the relevant factors have not been held constant; the given industrial relations practice is the optimal one for any given plant, but labor productivity varies for reasons other than those observed in the data. I find the second explanation more plausible, especially since the variation among plants is probably stable over time. The authors could certainly check to see whether this is true. If it is stable over time, the firm should have learned that certain plants are more productive and have adopted the practices used there.

The major measurement problem has to do with the failure to measure capital. A reduction in hours worked, although perhaps the best measure of improvement in productivity, is not sufficient. For example, suppose that one particular industrial relations approach creates so much tension between management and labor that management chooses to reduce its labor force dramatically and emphasize robotics to avoid conflict that comes from having to deal with people rather than machines. The authors would observe that as an improvement in productivity because labor hours per automobile fall, when in fact unit costs have risen. The authors are clearly aware of this problem, but some attempt to adjust for it might be important. This comes up specifically in a number of contexts. One of their dependent variables for measuring productivity is the number of supervisors. If supervisors increase but workers decrease sufficiently, unit costs could have gone down. This is the equivalent of not holding capital constant—in this case the capital is supervisory capital. They also use grievances per hundred workers as a measure of labor-management conflict. One way to reduce grievances is to fire those workers who make the most trouble or somehow induce them to leave. Such a policy could reduce grievances per hundred workers but might increase unit costs.

Measurement problems also come up in the context of the authors' test for efficient wages. Although some models, namely those that result in markets that do not clear, require that the wage at one plant be higher than the wage in the community as a whole, other models that provide for increases in effort do not require higher wages. Rather, they require that the age-earnings profile be steeper but that the average level of wages can be the same as elsewhere. Specifically, my mandatory retirement model argues that workers are paid less than they are worth when they are young and more than they are worth when they are old as an incentive mechanism. This could very well leave the average wage at the firm equal to the average wage in the community, but slopes would be different. It would be interesting to see whether the slope of the age-earnings profile, rather than the difference between wage at the firm and wage elsewhere, has an effect on the measures of productivity.

A final measurement problem concerns the accounting data by John Krafcik that the authors cite. Many years ago, Milton Friedman pointed out that accounting data, appropriately compiled, will attach value to specific resources that make a firm more productive. For example, a farm located on better land should account for the rental price of the land at a higher rate than a farm located on poor land. In the limit, if factors are priced appropriately, accounting profits at all firms must be the same. Thus if different countries use different methods for evaluating specific resources, accounting data will have little validity in terms of real unit cost.

As for interpretation, the first difficulty concerns the principal components method. I find the names associated with the variables that the authors construct somewhat problematic. They would like to interpret *RULES 1*, for example, as teams by looking at the component loadings important in constructing that variable. Although this may be all right for some purposes, a better approach would be to include the variables that seem to count most directly in the regression and leave the others out. Researchers must, of course, choose which variables to include and which to exclude. For example, labor economists generally put *WAGES* as the dependent variable and do not create some variable called *COMPENSATION* that is a blend of wages, vacation time, pension benefits, and so forth. The reason is that most researchers believe the pecuniary component is the most important. Similarly, the authors should confine their attention to the more straightforward empirical approach. They report these more traditional regressions in the analysis, and I wish they would emphasize them to a greater extent than the principal components approach.

A second problem of interpretation has to do with the findings that a higher wage is associated with more supervision. There are a number of ways to interpret this finding. One is that workers must be compensated more if they work under closer supervision. Another is that the supervisor's wages are included in the average plant wage. Since supervisors earn more than workers, higher plant wages might reflect more supervision. My guess is that *WAGE* excludes the wages of supervisors, but this is not made clear in the paper. Even if that is not true, however, it is certainly the case that the age structure of the firm would affect the average wage, and I do not believe that structure was held constant in the appropriate way.

Another difficulty of interpretation has to do with the number of jobs learned by a particular worker. The authors assume management likes employees to be flexible and that workers do not. Again, if compensation is allowed to vary, the reverse may be true. Management might prefer workers to specialize in a certain task (along the lines of Adam Smith), whereas workers might prefer to learn a large number of jobs so that they would be better prepared if their current job situation were to change.

Let me conclude with a couple of technical points. First, when I saw that the data set was a panel, I thought that surely the authors would exploit the within-plant variation over time to obtain their results. Unfortunately, they spent very little time doing that, perhaps because the results were so disappointing. Most of their results come from analysis of cross-sectional variation rather than time-series variation for a given plant. Cross-plant variation may pick up too many other things. In the same vein, one would expect that productivity changes would differ depending on whether the institution of a particular industrial relations practice was anticipated or unanticipated. Anticipated changes mean that the firm is able to adjust capital, supervision, and other aspects; and labor is able to adjust in terms of demands for compensation and other work conditions. Again, I hoped that the time-series analysis might prove fruitful here.

In sum, there are a large number of potential difficulties with this paper. But the same can be said of almost any good empirical work. Katz, Kochan, and Keefe have taken a bold step toward providing us with some solid evidence on the effect of industrial relations practices on productivity. Despite some negative reactions, I find it the best available empirical work on the subject.

George C. Eads: This paper is an interesting effort to bring insights from the field of industrial relations to bear on the major changes taking place in American manufacturing. It seeks to answer the question, what effects are work rule changes having on economic performance? In particular, are work practices such as numerous job classifications "to blame" (the authors' words) for poor American productivity? Have the recent changes in work rules adopted in some American plants produced significant payoffs? If so, which changes have produced the largest improvements in performance?

To answer these questions the authors employ data from a major U.S. auto company, covering fifty-three plants in 1979 and 1986. The plants were engaged in a variety of operations, including the final assembly of vehicles, stamping, body fabrication, engine assembly, and the manufacturing of components. However, the authors make the most use of data on assembly plants. Indeed, though they do not say so specifically, one must assume that two of their four sets of estimated equations (the results reported in tables 2 through 5) use data only from assembly plants since the dependent variables in the equations make sense only for such plants.

The authors also review preliminary results from a study by John Krafcik, which is based on detailed investigation of manufacturing practices employed in thirty-eight assembly plants in thirteen countries.[1] Though Krafcik's work is not focused on labor relations practices to the extent this paper is, it does address many of the same questions. In preparing these comments, I have used both the version of the Krafcik paper to which the authors refer and a later version employing a somewhat larger and richer sample. Krafcik stresses that these later data should be considered as still preliminary. The authors' principal finding is essentially that team systems of production do not significantly improve auto industry productivity. This finding runs counter to the beliefs of many, including many in my own company, and also counter to Krafcik's preliminary results.

The authors' primary support is the statistically significant positive association they find in one of their four sets of equations (the one whose results are reported in table 3) between the variable *Teams* and the number of labor hours unadjusted for vehicle complexity that are required to assemble a car. They conclude that an increase of one standard deviation in *Teams* is associated with 7 hours and 28 minutes

1. John F. Krafcik, "Comparative Analysis of Performance Indicators at World Auto Assembly Plants" (Massachusetts Institute of Technology, Sloan School of Management, January 1988).

more assembly labor hours compared with the manufacturer's 1986 average of 32.73 labor hours. The authors do not actually measure whether a plant employs production teams. Instead, as they state in the section titled "Reducing the Dimensionality of the Survey Responses," *Teams* is a composite variable consisting of "questions with [factor] component loadings greater than 0.45 in the first component measure rules that are associated with team work systems. . . ." Thus it seems inappropriate for them to characterize their results, which turn out to be statistically weak in any event, as suggesting what might or might not occur in plants that employ true team systems, the sort of situation that Krafcik in fact examined.[2]

However, I would not want this disagreement to be misinterpreted. While the authors' econometric results, especially their results concerning teams, do not seem to stand up to scrutiny, I agree completely with their conclusion that an effective linking of labor relations practices with management practices is the key to achieving superior productivity. This is completely consistent with Krafcik's findings. He reports a positive correlation between productivity (adjusted for vehicle complexity) and a variable he labels management philosophy, one element of which is the use of team systems.[3]

My own view is that changes in work rules or the introduction of team systems are by themselves likely to accomplish very little. My staff has conducted detailed documentation of the team-based manufacturing practices employed at the GM-Toyota joint venture known as NUMMI.[4]

2. Krafcik gives a plant in his sample full credit for using teams only if it has used "a team-style organization for at least one year," the one year cutoff serving "to differentiate between those plants which have just started using a team-style organization and are therefore still in a transition phase and those plants with more established team organizations." A plant also is credited with using teams only if "each team has a team leader, who has the capability of performing production work" (p. 29).

3. Ibid., pp. 78–83. Katz, Lochan, and Keefe seem to go to unnecessary lengths to criticize Krafcik's results, commenting adversely on the quality of certain of the corrections that he had to make and indicating that the sample size might be too small to yield definite results concerning teams. In my opinion, Krafcik has done a careful job of collecting his data and purging it of extraneous influences. The information content of his individual data points seems high, and his results both internally consistent and highly plausible.

4. General Motors Economics Staff, *NUMMI Management Practices*, January 1987. This study, which was undertaken to understand the reasons for NUMMI's superior productivity and quality performance, was coordinated by GM Economics Staff and conducted by a multistaff team including representatives from NUMMI, the GM Technical Liaison Office at NUMMI's Fremont plant, GM's two car groups, many other corporate

It also has conducted cross-firm studies involving similar products produced by GM plants and by plants of its principal domestic and foreign competitors.[5] (Using similar products obviates the need to adjust for product complexity, the adjustment that bedevils Katz, Kochan, and Keefe.) This latter work found that team systems are not uniform either in structure or effect.[6] Some plants were able to achieve productivity levels nearly as good as NUMMI's without the use of teams. In other plants, the use of teams did not seem to improve productivity. (I am unaware of any documented case in which teams have impeded productivity, the result that Katz, Kochan and Keefe report.)

What the studies find is that, when used as part of a well-defined and internally consistent manufacturing system, a properly structured team system can be a powerful force for increasing productivity and improving product quality. But a crucial requirement for making team systems pay

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staffs, and the UAW. The study has important competitive implications and so has not been made available to the public.

The methodology employed was similar to that Krafcik used. Members of the study team visited NUMMI and the GM Technical Liaison Office several times, conducting many interviews with NUMMI and GM personnel. They also visited several of NUMMI's suppliers to discuss their relationship with NUMMI, interviewed GM experts on Japanese manufacturing techniques, studied NUMMI materials, and read a variety of articles and books on NUMMI and on the Toyota production system on which NUMMI's system is based. Employees at the Technical Liaison Office and NUMMI managers commented extensively on drafts of the report.

To contrast NUMMI practices with those of GM, team members interviewed GM executives and visited GM assembly and component plants. At the plants, top management, first-line supervisors, and hourly workers were interviewed to get as many perspectives on GM as possible. Because practices at GM vary from group to group, division to division, and plant to plant, most comparisons to GM were based on what the team determined to be typical GM practice and are not specific to any GM facility.

The study yielded other quantitative and qualitative results. The former are reported in tabular form. No effort was made to utilize multiple regression techniques.

5. General Motors Truck and Bus Group, *Truck Manufacturing Practices Study,* August 1987. This study, which is also proprietary, was coordinated by GM Economics Staff and conducted principally by Truck and Bus Group staff and GM Economics Staff. It followed the NUMMI study, and there was some overlap in the two study teams. The *Truck Manufcturing Practices Study* focused on a single kind of light truck produced by both GM and its principal domestic and overseas competitors; it sought to explain major productivity differences observed across both the GM facilities producing the product and plants of GM's competitors.

6. Some of the GM facilities studied used forms of team systems, though in no case were these teams used in the way NUMMI's teams were. Some of the relatively more productive facilities of GM's competitors used teams and some did not.

off significantly is that management practices, as well as other important labor relations practices such as policies concerning layoffs, be changed.

All team systems are not alike, and differences in team size and the degree of autonomy given teams can produce important differences in results. For example, teams at NUMMI consist of four to six workers as opposed to teams of fifteen to twenty at two GM facilities. Rotation is mandatory at NUMMI while GM relies primarily on voluntary rotation. What makes NUMMI's team systems different is what the company calls standardized work, in which each job is documented in detail. All workers must perform each job in exactly the same manner: no individual differences are allowed. This description makes NUMMI sound like an extremely rigid system, one that Katz, Kochan, and Keefe would consider favorable to management. But something quite different is involved. In fact, at NUMMI the workers develop their own work rules. (To do this, formal work rules must be few and job classifications very flexible.) If a worker thinks he has a better way to do a job, he must convince the team to adopt his method. Job documentation is continually revised based on suggestions. As efficiency is increased, slack is concentrated in one job per team. Mandatory rotation ensures that every worker regularly gets the job with slack time. By concentrating slack into one job per team, productivity improvements become visible to both team members and management. As more slack develops, the line is rebalanced among teams, and labor is removed from the line.[7]

The differences in team sizes between NUMMI and other GM plants employing team systems raise a question about one of the authors' dependent variables—the number of first-line supervisors per one hundred production workers. They intepret a lower value of this variable as being associated with better performance. But is it? Our experience suggests that it is difficult in team systems, especially as employed at NUMMI, to identify just who is a first-line supervisor. The team leader at NUMMI is an hourly worker but performs important supervisory functions. If the team leader is considered a first-line supervisor, the ratio of such supervisors to production workers is 1 to 5 at NUMMI, much higher than would be the average for other GM plants (even plants that also employ teams). Yet I certainly would not conclude that NUMMI was

7. This rebalancing and removal of labor from the line does not lead to layoffs. NUMMI is committed to maintaining employment in the plant except in extraordinary circumstances and has done so in the face of major cutbacks in demand for its products.

performing poorly because of this. Consider also the matter of adjusting assembly hours per vehicle for differences in vehicle complexity. The authors do this in the regressions whose results are reported in table 4. But they do not do so in the critical table 3 regressions.[8] They justify this omission by expressing concern about the validity of the way the company whose plants they surveyed corrected for vehicle complexity.

Based on their description of this correction method, I share their concerns. But the solution is not to avoid correction altogether. That implies that, all else held equal, a complex car such as the Cadillac Seville should take the same number of hours to assemble as a relatively low-content Chevrolet Cavalier. This is obviously incorrect, and the failure to make some sort of adjustment for complexity renders the table 3 results highly suspect.

Finally, this paper reflects an increasingly outdated mind set. It embodies the adversarial tradition that historically has characterized American labor-management relations. This is explicit even in the way the variables are constructed. The authors divide them into those "favorable to management" and those "favorable to labor." What we in the auto industry are learning is that this sort of adversarial thinking will no longer work. GM's recent agreement with the UAW, as well as what has been learned from NUMMI and other examples, should be interpreted in that light. If we are to compete successfully with the transplant facilities that are springing up throughout North America, not to speak of the facilities that are being built elsewhere around the globe, we must change both our industrial relations practices and our management practices. Team systems are likely to be an important part of this change. But by themselves they will accomplish little. The Katz, Kochan, and Keefe paper performs an important service by emphasizing that fact.

General Discussion

The authors and other participants agreed that the most surprising result of the study was the failure to find evidence that the use of teams contributes to plant productivity. Harry Katz suggested that this failure

8. To repeat, this is the only set of equations in which the *Teams* variable is statistically significant.

may be a consequence of the particular way the use of teams was identified and measured—in effect, a team structure was inferred from the presence of certain work practices and work rules. This approach was limiting, the authors conceded, adding that their results must be interpreted in that light.

Kim Clark suggested that a straightforward way to interpret the authors' results would be to take seriously the implication that, in fact, teams do not improve performance, at least teams as they are implicitly defined by the authors' methodology. Rather, he suggested, what really matters may be the effects of worker participation and the integration of the people into the production process—both of which could be achieved with different work structures. One way to test this might be for the authors to decide more specifically what they think a team system is and then split the sample into those plants with teams and those without. He also suggested that the use of team systems may have a more important influence in dimensions of quality not picked up in the data, such as the ability of the plant to adapt to change or respond to unexpected events.

Similarly, Thomas Kochan noted that related work by John Krafcik attempted to measure not just the presence of teams, but how well teams are integrated into the manufacturing process. The degree of integration, Kochan added, is critical to understanding the role of teams. But he doubted that companies are systematic in integrating their choices of technology or other aspects of their production process with their human resource management. Some plants have made massive investments in technology without fundamentally altering their labor force or their labor-management relations, while others have made moderate changes and still others have made major changes.

Katharine Abraham took issue with Edward Lazear's argument that a reduction in the number of labor hours required per automobile might not constitute an improvement in productivity because it may involve a cost trade-off somewhere else, perhaps, for example, in higher wages. Since this study involved plants from a single firm, she pointed out, wages were uniform among the plants in the sample, so that a reduction in labor hours clearly represented a decline in labor cost. Lazear responded that the "wage," even if uniform across plants, is affected by average hours. A change in hours may affect the average wage paid within the firm. Additionally, the reported wage is likely to be some aggregate of the wages of various worker types, which would reinforce the validity of the point. Paul Joskow was puzzled by the evidence of significant and persistent productivity differences among plants in the same firm and suggested that the study would be illuminated by some discussion of how work rules are chosen, and how they are diffused among plants within the firm.

Robert Crandall raised questions about the heterogeneity of the sample, noting that the choice of technology in a plant might be endogenous with respect to labor-market conditions and therefore correlated with some of the explanatory variables. Since the type and quantity of capital used in the plant would also affect the measures of productivity used as dependent variables, this would confound the reported results. He also noted that the study failed to control for variations in the quality of the labor force. Katz noted that labor-quality measures exist, but were not made available to the researchers, so that this adjustment could not be made.