HOW INDUSTRIAL RELATIONS AFFECTS PLANT PERFORMANCE: THE CASE OF COMMERCIAL AIRCRAFT MANUFACTURING

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This analysis examines how changes in major industrial relations policies affected productivity over the years 1974–91 at one of the most important manufacturing plants in the United States. The authors find that productivity fell greatly, both in percentage terms and in absolute dollars, during strikes and a slowdown and during the terms of office of tough union leaders. In contrast with much of the firm performance literature, they find only small initial productivity effects of a movement from traditional adversarial management, which is the norm in this industry, to total quality management (TQM) and back again. How and why TQM is adopted, the authors suggest, may be as important as whether it is adopted. Finally, major industrial relations events like strikes, a slowdown, and the TQM program did not have long-term productivity effects; the firm returned to pre-event levels of productivity within one to four months.

Unionism per se is neither a plus nor a minus to productivity. What matters is how unions and management interact at the workplace.

—Richard B. Freeman and James Medoff, *What Do Unions Do?* (1984)

The productivity impact of industrial relations events has important implications for the health of both unions and firms. This paper examines how changes in industrial relations policy spanning the spectrum from cooperation to conflict affected productivity at one of the most important manufacturing plants in the United States over a period of almost two decades. Our strategy for gaining insight into this fundamental issue is to conduct formal statistical tests conditioned and qualified by firm-specific knowledge we gleaned from interviews with production managers and union leaders.

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We use information gathered from a large U.S. commercial aircraft manufacturing firm during a period when the United States dominated world production in this industry. The firm agreed to give us information from its main management information system database, with the condition that we not use its name in our study. We call the company Big Plane, or BP. One advantage of our information relative to data gathered from surveys (for example, the Census of Manufactures Longitudinal Research [LRD] Database file) is that we would expect it to be more accurate and detailed. In general, firms have a strong incentive to check the quality of internal data, since such data are gathered at considerable cost to the firm and are used for making policies within the organization as well as for developing corporate strategies.

We examine industrial relations practices within the framework of a production function analysis. A unique aspect of our study is the opportunity to examine the impact of industrial relations within the firm by reducing unobserved heterogeneity in production, a problem that has plagued other studies that use many industries, plants, or products with differing input requirements. We do this by examining, over a relatively long period, one plant that produced a standardized product with largely the same production work force and little change in assembly technology. We also examine institutional and historical events that occurred in the plant during the period of our analysis, as well as production-related factors like the learning curve. We focus on the leaders of both the local union and management and their interaction in creating the industrial relations climate that affected productivity in the plant. We empirically assess the effects of industrial relations factors on production using time series regressions. We also present a counterfactual simulation to illustrate the effects of a total quality management (TQM) program, as well as other important labor-management events (Freeman and Kleiner 1998).

The Industry and Firm

The aircraft industry is of particular importance because it has been one of the dominant exporters of high–value-added goods in the U.S. economy. In 1995 the U.S. aircraft industry recorded a trade surplus of $21.3 billion, or about 57% of total commercial export volume (Napier 1996). The industry is the second largest employer of manufacturing jobs in the United States, behind only automobile manufacturing. The assembly of the final product, which is the primary contribution of the firm we study, includes elements of both mass and custom production. Although the assembly process is similar across planes, at least some aspects of commercial aircraft are typically customized for the customer. During the past decade the industry in the United States has faced increasing competition from Airbus, a European producer.

One of the main variables allowing the United States to maintain its competitive advantage in aircraft manufacturing is its high level of factor market competitiveness, including managerial talent, sound manufacturing policies, and the productivity of its production work force (NRC 1985). The huge entry costs in this industry have largely precluded new entrants and encouraged consolidation (Golich 1992). In the absence of dramatic technology shifts, the steep learning curve in this industry also favors incumbents.

Learning curves were first applied to explain the improvement in aircraft production with greater experience (Asher 1956; Arrow 1962). As management and workers learn to become more efficient, productivity increases with cumulative output. More recent estimates of the learning curve have shown generally improved learning in production assembly of large commercial aircraft, with some modifications to the trend to account for what has been labeled "organizational forgetting" (Benkard 2000). The learning curve in this industry is a dominant predictor of productivity that we will control for in our baseline estimates. We will also examine more deeply the fundamental industrial relations question of how the policies and practices of management and labor affect productivity.

The aircraft assembly process that we used to examine the role of industrial relations policies and practices requires huge investments in capital and substantial research and development. Long product development periods, sometimes exceeding a decade from the research and development stage to the roll-out of the final product, are common in this industry. The product cycle is also long, frequently exceeding 20 years. The huge initial investments and limited number of industry rivals present opportunities for economic rents. Given the oligopolistic structure of the commercial aircraft industry, unions have been a major factor, and have succeeded in obtaining high wages and benefits for their members (Karier 1985). Labor costs as a percentage of total value added are low, but hourly earnings of production workers are about 40% above the average wage in manufacturing, resulting in low voluntary quit rates (Kleiner, Nickelsburg, and Pilarski 1995).

But economic success in the product market has not necessarily meant peaceful or harmonious industrial relations. Throughout the post–World War II period the major aircraft firms have generally had acrimonious labor relations, with strikes, work slowdowns, and threats of work stoppages playing a regular part in the collective bargaining process. Unlike most other industries, where strikes rarely occur, the firms in this industry endure concerted activities during most contract negotiations (Erickson 1994). In recent years, in response to greater foreign competition, several attempts have been made by both labor and management to change the focus of industrial relations in the industry from confrontation to cooperation.

BP's economic performance roughly mirrored that of the rest of the industry through 1983, after which it lost ground to competitors. The industry is highly cyclical, and the firm we studied accounted for 25–30% of total industry output, employment, and revenues in the United States. In tracking the firm over time, we found that its experiences resembled economic changes that occurred in the industry at large.[1]

Industrial Relations Policies and Productivity

Employee involvement, gain-sharing, and other high-performance workplace practices have been discussed in recent industrial research literature, and also have taken on an important role in policy debates. A number of case studies have suggested that firms or plants characterized by cooperation, employee involvement, and relatively low grievance rates tend to have higher levels of productivity (Katz, Kochan, and Gobeille 1983; Cutcher-Gershenfeld 1991; Lewin 1999; Rubinstein 2000). For example, the Dunlop Commission discussed employee involvement and related high-performance practices as a way to enhance American competitiveness and raise aggregate productivity (Commission on Labor Management Relations 1994).

Data from a wider variety of firms followed over time show that high-performance workplace practices have only small or statistically insignificant effects on plant-level productivity (Cappelli and Neumark 1999). Another longitudinal case study found that the impact of tougher supervision and the optimal monitoring and discipline of a work force, rather than employee involvement, can lead to productivity gains within a firm (Kleiner, Nickelsburg, and Pilarski 1995). How industrial relations policies are implemented may have greater importance than whether they are implemented.

Our case example includes labor-management bargaining pairs that resulted from both the firm and the employees choosing leaders partially in response to the leadership characteristics of the other party, and

[1]Due to the proprietary nature of the data, without going to the company for further permission to distribute the data to other researchers, we can only provide the data in the tables.

then having the other side act in its own interests.[2] Both union and company leadership changed over time, sometimes with explicit changes in ideology or approach. The firm we examine is shareholder-driven, with multiple operating divisions competing internally for corporate resources. Plant management is not entrenched. Rather, the top management of this plant can be and has been replaced, sometimes after unusually brief terms in office, under pressure from shareholders, customers, and top corporate leaders. Although we cannot formally or rigorously test for the existence or optimal timing of a particular match of industrial relations leaders relative to a random draw, we can provide some insights into how particular pairs of union and management leaders affect productivity, and how this compares with predictions from the personnel economics and industrial relations literature.

Theory predicts performance effects from matching between managers and union leaders. One expectation is that a bargaining relationship between two tough leaders, or "hawks," will generally produce a higher-productivity environment than will a bargaining relationship between a hawk and a "dove" (Lazear 1995). For example, production employees may be more likely to reduce their effort if they think that a tough manager is paired with a weak union leader rather than a strong one. A strong manager concerned mainly with short-term profit maximization will be likely to reallocate more of his or her efforts toward profits and away from wages if the union leader is weak and unwilling to use bargaining leverage. In this theory, those on the management or union side may, in choosing a leader, try to match the perceived toughness or conciliatory tendency of the leader on the other side, with the result that pairings of management and union leaders—and any productivity effects of those pairings—will be non-random.

The Production Function Model

We enrich a production function to allow for the possible effects of labor policies and practices. We start with a standard production function

(1) $$Q = AL^{\beta}K^{\gamma}v,$$

where K is capital, L is labor, Q is output, and v is a log normal random variable that captures the idiosyncratic random element in production. We assume that

(2) $$L = N \times H \times S,$$

where N is the number of workers, H is the number of hours, and S is the intensity of effort of the workers. Substitution of equation (2) into equation (1) yields

(3) $$Q = A(NHS)^{\beta}K^{\gamma}v$$

(4) $$NHS = f(IR)$$

The industrial relations environment is assumed to influence the level of output by

[2]The time-invariant productivity of a particular match can be learned over time during negotiations. In addition, leadership can matter during the administration of a contract when the interpretation of provisions is settled, a process commonly known as fractional bargaining (Kuhn 1961). Consistent with the economics literature, matching of the pair is thus an "experience good." The learning process is such that a noisy observation on true productivity arrives on each date t. Furthermore, as t increases and more observations are accumulated, the precision of productivity (prod) estimates of the pair will improve. The discontinuation, d, for each P_t conditioned on the productivity level can be written as

$$d(\text{prod}, t) = \alpha F_t(\text{prod}^r(\text{prod}, t)),$$

where $F_t(*)$ denotes the time t estimate for the productivity distribution for the current pair P_t, and α denotes the receipt rate of productivity observations. Although productivity is a constant in the equation, the learning process implies that the productivity of the match will change over time. A particular match will continue as long as productivity is sufficiently high (a) to satisfy shareholders (from management's perspective) and (b) to satisfy workers by providing the basis for good high wage gains and employment security (from the union view). Generally the d from the union side would come at a regularly scheduled election, whereas managers can be replaced at any time. In our case study there was high turnover in union leadership.

changing the intensity of effort (S), as well as the hours worked (H), and the number of employees (N) in equation 4. L, H, and S in the assembly of planes would be affected by strikes, slowdowns, statements by union and management leaders, and policies such as total quality management, and these effects, in turn, would influence productivity. Therefore, substitution into (3) yields

$$(5) \qquad Q = Af(IR)^{\beta}K^{\gamma}v,$$

where output (Q) is a function of industrial relations (IR) policies and practices and capital.

This specification explicitly takes into account how industrial and labor relations influences the production function.

Quantitative and Qualitative Data on Production

Most other studies of the economic performance effects of industrial relations variables such as strikes, work-to-rule, or contracts have used stock market returns or firm-level profits as the relevant measure of the outcomes of these labor relations events, even though the events often occur at a single plant of a multi-plant facility or within a single business line of a multi-business line organization (Becker and Olson 1987). Consequently, any effects of these events are biased downward by being mixed into a larger aggregate. The direct effects of these events are likely to be much larger if they are measured at the level of the establishment they directly affect.

We use information compiled by BP on monthly production of its principal commercial aircraft in its main plant from January 1974 through November 1991, for a total of 215 monthly observations (almost 18 years). We focus on one general model of plane. We use as a control variable information on the planned rate of monthly production for a companion aircraft, produced on another assembly line in the same plant. The plane we focused on in this paper was redesigned and updated in 1980. This caused major changes in productivity as workers learned the new production processes necessary for the updated model. The plant-level information was gathered for internal use by analysts and business economists in the plant as their basis for developing business plans and for internal managerial accounting information systems in the organization.

To add depth and greater understanding to these statistics, we engaged in several on-site interviews with many of the top production-related managers and union leaders in the plant, who told us about current and past officers and their policies toward labor relations. Perhaps because the swings in industrial relations policy and practice within the plant were so dramatic and open, we found nearly complete consensus on the nature, timing, and consequences of these changes. Surprisingly, there was even widespread agreement on why various initiatives had failed.

A unique aspect of our study was our detailed discussions of production-related issues as well as union politics with the leadership of the local in the plant.[3] We were able to obtain information on the leadership styles and objectives of the relevant union leaders as well as their attitudes about productivity-enhancing policies during their tenure in office. These interviews also focused on their opinions about cooperation versus confrontation with management in the plant. For example, different union leaders' attitudes ranged from support for the adoption of TQM with high levels of employee involvement and a promise to implement gainsharing, on the one hand, to an explicit desire for a confrontation with management over work issues, on the other.

Our measure of productivity is the monthly difference between actual and planned standardized hours of labor for the assembly of each plane per month. This specification allows us to difference

[3]A more detailed documentation and accounting of the political events, details of the union elections, and union steward politics can be found in Kleiner and Pilarski, forthcoming, pp. 103–19.

out the effect on productivity of any variable whose effect is anticipated by management in its forecast, whether or not we measure it directly. The firm recorded the standardized number of person hours per plane, and this was calculated and audited internally by the production quality control persons in the plant as the full-time employee equivalent number of production hours that was assigned to each plane by first-line supervisors. Planned labor input is an internal management forecast, made about two years in advance, that takes account of learning in production, technological advances, capital per worker, government regulations, and anticipated demand for output, but does not factor in parts shortages or changes in the industrial relations environment.[4] Given the frequent turnover in labor and management leadership, the internal forecasters did not know who might be the labor or management leader in the future. The major innovations in the production process are captured by the learning curve. The planned rate forecast also assumed a continuation of the existing work force, effort, and hours in production. The planned labor input per plane is viewed as occurring under optimal conditions, and we would expect it to lie below the actual level of labor input.

In Figure 1, panels 1, 2, and 3 show the timing of the major industrial relations events, including major union and management leaders, strikes, slowdowns, model changes, and the implementation of TQM (which included elements of employee involvement) against productivity, measured by standardized hours per plane per month. Panel 1 shows the actual and planned hours during the period from January 1974 through July 1991. Panel 2 gives the *difference* between actual and planned hours over the same time period. The major industrial relations events earmarked in this panel—the three strikes, and to a lesser extent the work-to-rule episode, the model change, and the introduction of total quality management—plainly coincide with spikes in the difference between actual and planned hours of work. Finally, Panel 3 presents the terms of office of the managers and union leaders.

The other key variables used to control for production-related factors were spantime, which is the average number of days it takes to assemble a plane during the month in question, the number of average weekly parts shortages for the month, the projected standardized labor hours needed to produce the other major airplane that is assembled in the same factory, and the number of planes delivered and accepted by customers per month as a measure of production congestion.[5] We explain these variables below, and discuss how they differ from what production engineers include in their estimates of the planned rate.

Spantime is a measure of the average workdays from start to finish for the assembly of each plane. We use it to control for the pace of production and the competing demands on labor and management in this plant during slack and high-pressure times. Estimates of spantime in this plant are made when the order for a plane is taken, which typically is many years in advance of delivery. Spantime is a component of the production schedule developed as part of the price and delivery date negotiations with the customer.

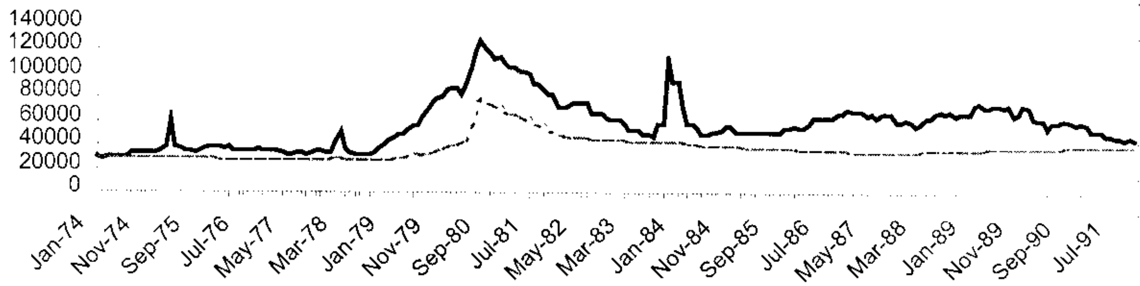
Records and interviews show that when production was accelerated to meet a production target at BP, spantime had two counterbalancing effects. Learning in production accelerated, but at the same time parts shortages increased. Parts shortages disrupted and slowed assembly. We directly control for the number of parts short-

[4]Although the planned rate anticipated the amount of capital per worker, we also estimated capital per worker using annual data obtained from the company's annual reports. This information was for the overall company. Capital per worker was not available on a monthly basis for the plant we analyzed.

[5]These detailed data are similar to other firm-level data obtained in a study of the auto industry (Raff 1996).

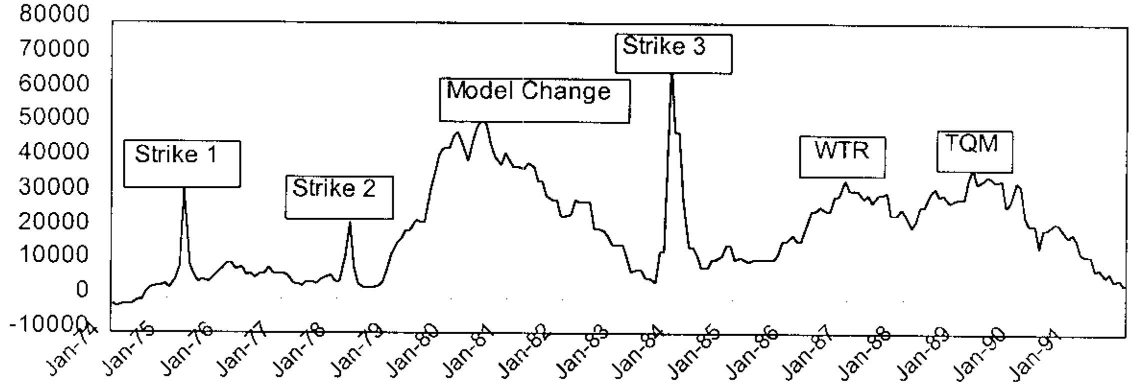
Figure 1. Labor Costs and Time Periods for Key Industrial Relations Events

Panel 1: Trends in Actual and Planned Labor Cost in BP (Hours)



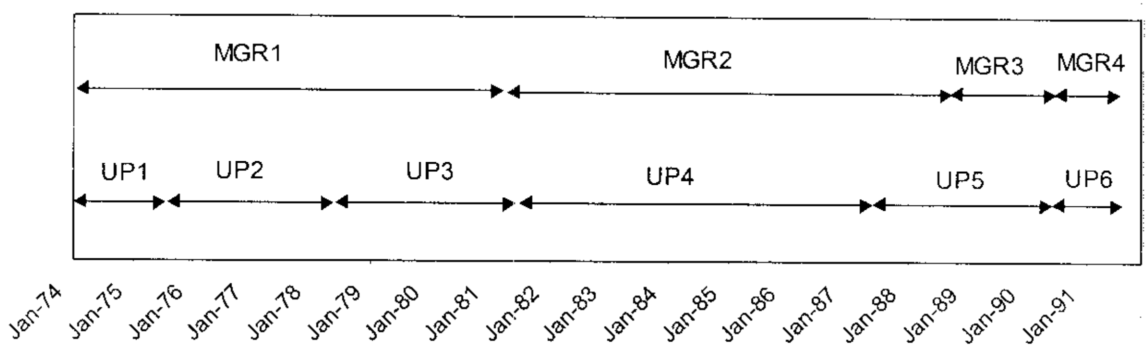
Note: Dotted line is planned labor cost. Solid line is actual labor cost.

Panel 2: Difference Between Actual and Planned Labor Cost in BP (Hours)



Note: Strike 1: Feb-May, 1975. Strike 2: Dec. 1977-Mar. 1978. Strike 3:Sept. 83-Feb. 1984.TQM: Feb. 1989 -Nov. 1990. Work to rule: Dec. 1986-Sept, 1987. Model Change: Jan. 1980-Dec. 1982.

Panel 3: Time Period of Union Presidents and Company Managers



Note: Union President 1: Jan. 1974-April. 75. Union President 2: May, 1975-April. 1978. Union President 3: May, 1978-April, 1981. Union President 4: May, 1981-April, 1987. Union President 5: May, 1987 -April, 1990. Union President 6: May, 1990-Nov. 1991. Manager 1: Jan. 1974-Feb. 1981. Manager 2: Mar. 1981-Dec. 1988. Manager 3: Jan. 1989-Aug. 1990. Manager 4: Sept. 1990-Nov. 1991.

ages, which is an unplanned variable, and we predict that this factor has a strong effect on labor productivity for airplane assembly. In order to maintain as long a time-series data series as possible, and also to capture as many labor relations events as possible, we estimated the mean value of the planned production and parts shortage variables, and controlled for any estimated values by including a dummy variable for these observations in our regressions (Little and Rubin 1987).[6]

Two major lines of aircraft were assembled in the plant. This gives us an opportunity to control for factors we do not measure directly that affected both lines. We used the anticipated numbers of hours of the other assembly process as a control for the demand for hours or work in the factory and material resources in the organization and as cross product demand in the production function. This control variable may also reflect organizational priorities in production for the plant, which would largely be determined by the relative demand for the other major product assembled in the plant. The true effects we are seeking to estimate probably lie somewhere between the estimates with and without the control for anticipated hours on the other line. To the extent that the labor relations events affected both lines, part of the labor relations effects will be captured by hours on the other line. We will then underestimate their effect by controlling for hours on the other line. This risk is worth running if unmeasured factors coincident with some of the industrial relations events we study affected productivity on both assembly lines. Controlling for anticipated hours on the "sibling" assembly line may limit this omitted variable bias. Consequently, we present results both with and without the controls for anticipated hours in the other line.

In making productivity estimates, researchers often have difficulty measuring the quality of the final product (Thompson 1999). In the case of large commercial aircraft, the final product is subject to many rigorous quality controls. For example, test pilots from the company must test the aircraft by flying it through rough weather. In addition, the Federal Aviation Administration (FAA) engages in several rigorous tests to certify the quality of the final product. Finally, the customer must accept delivery of the plane, for which it has paid many millions of dollars. Overall, the final product is a fairly standardized unit over time in which high quality standards are applied and certified through a number of tough independent tests.

Labor-Management Events in Production

The BP plant experienced a wide array of industrial relations events and conditions from the 1970s through the early 1990s. There were three strikes and a work-to-rule slowdown as a substitute for a strike during stalled negotiations. We are thus able to examine a variety of industrial relations events in considerable depth.

The strikes were of varying length (from one to three months) and intensity.[7] In the 1983 strike, which was the most bitter, workers threatened to destroy plant equipment, and management threatened to replace production workers if a quick solution to the impasse was not reached. The union ultimately settled for the same basic contract that was offered by management prior to the strike.

The frequency of strikes in the United States declined dramatically starting in the early 1980s. The experience of this plant shows the threat posed by an alternative tactic: an in-plant slowdown. Prior to the

[6]We also estimated the basic models with and without missing values and found consistent results for all the independent variables in our models.

[7]Four new labor contracts were negotiated during the period of our study that reflected a general movement toward greater benefits as well as enhanced flexibility for management to contract out work.

last labor agreement in our sample period, an in-plant slowdown lasting almost 11 months severely pressed management in ways it found difficult to counter. This tactic avoided the risks of a strike, which could have cost union workers wages and, potentially, even their jobs—hazards they had experienced in the strike three years before. Traditional work-to-rule procedures were implemented. Production workers strictly followed the letter of the previous contract. They refused non-mandated overtime work as well as other job assignments that were not explicitly spelled out in the labor contract. By thus lowering short-term productivity, the unionists sought to impose costs on the firm without imperiling their own paychecks or jobs.

The other major industrial relations event that took place during the period we studied was the implementation of a total quality management program (TQM). The introduction of TQM occurred from 1989 to 1990. This program included high levels of employee involvement and formal assurances of job security for production employees. A major objective of the firm was to drive employee grievances to zero, with the vice-president receiving a substantial bonus if formal worker complaints were below a certain level. First line supervisors felt jeopardized by the TQM program's reliance on self-managing teams with greater autonomy.

The content of TQM at BP was largely determined by emulation of New United Motors Manufacturing, Inc. (NUMMI), the joint General Motors/Toyota plant represented by the same union. The company tried to copy the policies and practices that had transformed NUMMI from an operation shut down due to low productivity and bitter employee relations to a plant with high performance. Toward this end, one of the first acts was to hire the executive in charge of implementing TQM at NUMMI, pay him well, and put him in charge of implementing TQM at BP. TQM at BP entailed delegating greater authority to line workers organized into partially self-directing teams, retraining line workers and supervisors, instructing line supervisors to replace authoritarian styles with coaching, and offering gainsharing bonuses. The intent was to implement a high-performance workplace by "involving employees in the decision making process in the areas of quality, problem solving and productivity."[8] As at NUMMI, employees were expected to suggest ideas for continually improving the assembly process.

While the intention was to form work-teams retrained in TQM, the needed critical mass of retrained workers was never reached, because production managers would not release masses of key personnel whose absence from the line would have threatened their ability to meet tight production delivery goals. Moreover, this period also coincided with a period of layoffs due in part to the inability of the company to deliver planes on time, which many in management and in the union attributed to the TQM program.

The process through which TQM is implemented is just as important as the content of any particular TQM program. At BP, TQM was instigated by the principal owner, with the cooperation of the union leader, in a top-down process that never fully won the embrace of the line workers or their front-line supervisors. TQM meant different things to different constituencies. To top management it was a way to bring greater profitability to the plant. To the international union leaders it was an opportunity to appear reasonable while empowering workers. To the local union leaders it was the wave of the future, a mature approach that promised to mitigate the conflict that had existed and use the knowledge of workers to help preserve their jobs and raise earnings. To a radical faction opposition inside the local union at BP, TQM was a sell-out to management, and an opportunity to embarrass local union leadership. To production managers, it was a drag on short-term productivity that took workers off the

[8]This was part of a joint statement of union leader 5 and company president 3 issued to all employees in 1988.

line for retraining in areas the managers thought were "squishy" and irrelevant to their jobs on the line.

Finally, to front-line supervisors, TQM represented a threat to their self-image, their prerogatives, and their positions. In a masterful and yet largely uncoordinated display of passive aggression, the front-line supervisors demonstrated their value by withdrawing from active discipline of production workers. As a consequence, for workers TQM became an opportunity to shirk. Supervisors' undeclared work-to-rule imposed a heavy cost that helped undercut TQM.

Union and Managerial Leadership's Impact on Plant Performance

Beyond the events listed above, the union and management at BP exhibited unique qualities that also may have contributed to productivity changes within the plant. An unusually vibrant democracy distinguishes this local union. During the years of observation, this local had the largest membership of any single plant local in the United Automobile Workers (UAW) in the United States and Canada. More than 22,000 members of the local union worked in the plant complex at the beginning of 1992, and few quit.[9] The union had high levels of competition for major officer positions. For example, several rival political parties with organized slates and contrasting ideologies vied for control of the local union. The political parties campaigned vigorously and explicitly stated their views of the appropriate level of militancy toward management. There has been much turnover at the helm. From 1967 to this writing, no union president has held office for longer than seven years. Six different union presidents, not all from the same party, served over the period examined (January 1974–November 1991).

During the early part of the period we examine, the union leadership subscribed to traditional adversarial labor-management relations. Union leaders 1 through 3 were relatively moderate in their bargaining styles and viewed strikes and other concerted activities as acceptable only as a last resort to obtain concessions from management on wages, hours, and other conditions of employment. Union leader 4, the most militant of the six leaders during the period of the study, campaigned on a platform of confrontation with management. To reallocate plant- and company-level rents toward labor, he advocated frankly combative tactics that were described by one manager as "crude class warfare." In 1983, he led the union and its membership through the longest strike in the history of the plant. He also developed and implemented an in-plant slowdown that many managers said reduced the opportunity of this plant to expand employment and resulted in the company building a new plant in a distant but more management-friendly state. Relations with the national office of the UAW became strained during his term in office. Toward the end of union leader 4's tenure, the international UAW declared the union to be in "receivership" because of poor management and loose financial controls. The international office of the UAW then greatly increased its monitoring and control of the local union.

After the period of polarization during this troubled reign, the international office of the UAW supported the election of union leader 5, who had the tacit support of management as well. Leader 5 campaigned on a promise to work closely with management and to establish the TQM program. He attended several national training sessions on employee involvement, and was committed to having the local union participate in the process. He was elected in 1987, in reaction to his predecessor's militance, and followed a more cooperative approach toward management than did any of the other five union leaders.

A decline in orders led to layoffs that exacerbated internal union problems, ultimately resulting in union leader 5 being

[9] The voluntary turnover rate among production workers at this plant was between 1% and 2% per year over the almost 18-year period of our study.

voted out. (Leader 5 went on, however, to win reelection in the mid-1990s, after he repudiated his earlier support of employee involvement and TQM.) The cooperative approach was associated in the minds of the union membership with layoffs and concessions to management. Union president 6 campaigned on a pledge that he would pull union support out of any TQM program, a promise he followed through on after his 1990 election. He vowed to restore the traditional confrontational tone of negotiations with the company as the best way to ensure that employees received adequate job security, controls over their jobs, and higher wages.

During the study period, management also had leaders with varying styles and approaches to governing the workplace. As background, BP was not involved in any significant mergers or acquisitions from the 1970s through the early 1990s. During the study period, the plant was led in succession by four presidents of commercial aircraft manufacturing, who held primary responsibility for industrial relations. The first company president's industrial relations policies conformed with the traditional adversarial behavior of labor and management in this plant. More specifically, his policies included tough top-down management, and distributive bargaining with the UAW local that was, in part, responsible for the strikes and work slow-downs that characterized labor relations in the plant—a pattern replicated throughout the industry during the post–World War II period (Walton and McKersie 1991). Both top level managers and other supervisors monitored the work force rigidly. They often used abusive language and reprimanded employees in front of their peers. Following the long and difficult 1983 strike during which management threatened to hire replacement workers, the second company president oversaw a gradual movement to quality circles, the forerunner of employee involvement in the plant. The third company president implemented the TQM program largely in response to a directive from the CEO of the parent company. The union's opposition to TQM undercut its implementation and pulled the rug out from under the third company president. He was replaced soon after cooperative union leader 5 lost his own reelection battle.

The disruption of operations during efforts to implement TQM threatened promised delivery dates and provoked threatening calls from key customers. Under growing pressure, management reversed its policy on TQM. The final company president reverted to tough discipline and turned back the policies and practices of his predecessor. Company president 4 thought that the TQM approach had resulted in a decrease in productivity, an increase in labor costs in the production process, and costly and damaging failures to meet delivery deadlines. Consequently, he engaged in strict monitoring, which some workers referred to as a "boot camp" type of management. Monitoring of production employees was tight, and discipline and grievances within the plant increased dramatically. For example, executives in the industry were quoted as saying that "the situation at 'Big Plane' is that we need more professional discipline through management, which will then reflect itself in the work force" (*Aviation Week* 1990). We use this last manager as the baseline for our statistical analysis, comparing productivity performance during each management leader's tenure to productivity performance during his tenure. In Figure 1, panel c, we show the time line for each of the union and management leaders, and we implement dummy variables to measure each person's term of office.

Estimating the Effect of Industrial Relations on Productivity

Industrial relations in the BP plant went through a number of major changes during the period we examined. The previous two sections describe some of the ways in which both the events and the management and union leadership changes, which at various times swung from one end of the

Table 1. Means and Standard Deviations of Key Variables for the Big Plane (BP) Company.

Variable	*Mean*	*Standard Deviation*
Average Standardized Hours per Plane	58,051.97	20,964.08
Estimated Hours per Plane	38,308.35	9,934.98
Estimated Hours per Second Plane Assembled in Plant	106,811.56	10,855.00
Spantime—Days per Plane	133.43	48.77
Parts Shortage (number of plane parts)	1,360.20	2,487.69
Manager 1	0.40	0.49
Manager 2	0.44	0.50
Manager 3	0.09	0.29
Manager 4	0.07	0.26
Union President 1	0..07	0.26
Union President 2	0.17	0.37
Union President 3	0.17	0.37
Union President 4	0.33	0.47
Union President 5	0.17	0.37
Union President 6	0.09	0.28
Strike 1	0.02	0.14
Strike 2	0.01	0.12
Strike 3	0.02	0.15
Work to Rule	0.05	0.21
Plant, Machinery, and Equipment per Person (in constant $)	1,225,000	474,000
Total Quality Management Program	0.10	0.30
Model Change	0.17	0.37
Planes Delivered per Month	5.63	4.06

cooperation-conflict spectrum to the other, may have affected productivity. The occurrence of these extreme swings in industrial relations within a plant producing a fairly uniform product with a stable process technology gives us an opportune setting in which to examine the impact of industrial relations on productivity.

To assess this impact, we use two different strategies. First, where possible, we use time-series regressions to estimate the effect of the principal labor leaders, managerial leaders, and industrial relations events on a key measure of productivity—namely, the standard number of hours to assemble the large commercial aircraft relative to the expected number of hours.[10] The dependent variable is the deviation of actual production from planned production. In these OLS regressions the explanatory factors are a monthly time trend, the lagged logarithm of the dependent variable, two measures of the learning curve (the start of production and the change to a new model), the number of delivered planes per month, days from beginning to completion of the aircraft (spantime), and dummy variables for the labor, management, and industrial relations variables in our model. To account for potential endogeneity in our model, we test alternative specifications. Potential factors that may be endogenous are likely to have minor effects. For example, even factors such as the number of delivered planes in a month are estimated years in advance, when the initial contracts are signed. Moreover, when delays occur in the production process, workers are required to work overtime or more employees are reallocated to the plane from another part of the plant to meet the targeted production schedule.

Our second method of analysis of labor and management practices is an ARIMA-type auto-regressive forecast whereby we specify a particular counterfactual situation in the plant and estimate productivity levels under those altered conditions. Specifically, we estimate what level of productivity would have occurred in the absence of each of the observed industrial relations events, which ranged from strikes and work-to-rule to the implementation of the TQM program, and we use some of the estimated regression parameters to contrast estimated productivity with actual outputs. In the case of the total quality program, we then follow the firm to its last industrial relations

[10]In addition to the estimates presented in the tables, we performed a production function estimation with actual production as a function of planned production and the other independent variables in our model. The qualitative results are virtually unchanged, as are the levels of statistical significance. These results are available from the authors.

event in our analysis, which was the implementation of a rigid monitoring scheme with strict discipline and less voice by employees in day-to-day operations.

Table 1 shows the means and standard deviations of the production-related factors and industrial relations variables used in our multivariate models of productivity.[11] The learning curve variables are calculated as the logarithm of the total number of hours of production from the beginning of the period and the logarithm of that value squared. In 1980, the plane was substantially redesigned. To account for this change, we include a second learning curve. We control separately for the logarithm of cumulative hours on the redesigned plane and the cumulative hours squared.

These controls reflect both factors discussed in the productivity literature, and the models that the production economists in the plant used to analyze productivity. The table also shows that the complementary larger plane assembled in the same plant took about 80% more estimated standardized hours to assemble than the plane we employ as the dependent variable in our analysis. All other variables in the regressions are dummies reflecting the time period over which each industrial relations variable was in effect. We include separate dummy variables controlling for the term in office of each of the union and company leaders.

Tables 2 and 3 present regression estimates of the impact of industrial relations factors on productivity. In Table 2 the OLS estimates correct for first order auto-correlation of the errors, because we use the lag of the dependent variable consistent with appropriate time-series model specifications suggested by Harvey (Harvey 1981). In Table 3 we drop the lagged dependent variable and include a measure of capital as measured by the logarithm of machinery, plant, and equipment per person, which is consistent with our theoretical model.

The results are generally consistent across both specifications.[12] In column (1) of Tables 2 and 3 we present the effects of industrial relations factors without controls for production-related variables that are generally included in productivity analysis (Benhard 2000). A common problem of historical interpretation is the difficulty of distinguishing a leader from the events of his day. Column (1) focuses on the overall effect of industrial relations factors on hours per plane without production-related variables. In this specification only the second and third strikes are statistically significant. Column (2) in Tables 2 and 3 focuses on the union and management leaders and production-related variables along with a time counter variable. In column (2) in Tables 2 and 3 we use only industrial relations events, which include strikes, work-to-rule, and the TQM policies with production controls and a time counter. Columns (4) and (5) of Tables 2 and 3 show the events and leadership variables that the various labor-management leaders implemented with the production-related variables, with the planned estimates of the second plane omitted from the specification in column (5).

The results in Tables 2 and 3 with production controls are generally consistent with accepted views of the role of strikes and work stoppages in reducing productivity and firm performance (Becker and Olson 1987). The third strike was the longest and most bitter one, and it reduced productivity the most (column 3). This is not quite a

[11]We also estimated models by using moving average smoothing techniques for monthly labor costs and found no qualitative differences in our results. Additional controls for the duration of the labor contract also showed the same qualitative results.

[12]Panel A includes a more accepted econometric specification of time-series and assumes that the production managers included a level of capital in their estimates of the planned rate. Panel B drops the lagged dependent variable and explicitly includes a measure of capital per worker as in a Cobb-Douglas production function. Since both specifications have merit, we include both estimates in the table.

Table 2. Impact of the Overall Industrial Relations (IR) Environment on the Log of Difference between Actual and Planned Hours per Plane in the BP Plant, with Lag of Dependent Variable as One Independent Variable.

Independent Variable	*Overall IR Factors without Non-IR Controls (1)*	*Leadership-Related Factors (2)*	*Event-Related Factors (3)*	*Overall IR Factors I (4)*	*Overall IR Factors II (5)*
Constant	1.16* (.37)	28.67 (57.34)	146.84* (31.96)	84.69 (53.15)	−28.90 (50.76)
Strike 1	.19 (.16)		.80* (.17)	.41* (.18)	.56* (.19)
Strike 2	.58* (.16)		.63* (.18)	.38* (.18)	.32 (.18)
Strike 3	.24* (.13)		.50* (.18)	.51* (.17)	.39* (.15)
Work to Rule	.07 (.09)		.38* (.10)	.24* (.10)	.26* (.10)
Union President 1	.10 (.28)	2.05* (.37)		1.64* (.35)	1.43* (.36)
Union President 2	−.18 (.25)	.75* (.31)		.72* (.30)	.52 (.31)
Union President 3	.10 (.25)	.50* (.27)		.44 (.25)	.51 (.27)
Union President 4	−.01 (.16)	.54* (.20)		.46* (.18)	.53* (.19)
Union President 5	.05 (.15)	.44* (.16)		.34* (.15)	.30* (.15)
Total Quality Management Program	.10 (.14)		.07 (.07)	.15 (.13)	.01 (.13)
Manager 1	.15 (.26)	.44 (.27)		.42 (.25)	.22 (.26)
Manager 2	.18 (.18)	.43* (.18)		.40* (.17)	.18 (.18)
Manager 3	.10 (.19)	.30* (.15)		.16 (.16)	.12 (.17)
Spantime		−.00 (.00)	−.00 (.00)	−.00 (.00)	−.00 (.00)
Log (Parts Shortage)		.03 (.02)	−.09* (.02)	.07* (.02)	.09* (.02)
Time Trend		.02* (.01)	−.03* (.01)	.01 (.01)	−.01 (.01)
Log Learning Curve—Model 1		30.10* (8.35)	−5.35 (5.78)	18.72* (7.97)	3.37 (7.54)
Log Learning Curve Squared—Model 1		−1.1* (.31)	.22 (.22)	−.68* (.30)	−.09 (.28)
Log Learning Curve—Model 2		−.28* (.20)	.21 (.16)	−.08 (.17)	.06 (.18)
Log Learning Curve Squared—Model 2		.02 (.02)	−.02* (.01)	.00 (.01)	−.01 (.01)
Lag of the Dependent Variable	.86* (.04)	.69* (.05)	.64* (.05)	.61* (.05)	.69* (.05)
Planes Delivered per Month		.01 (.01)	.00 (.01)	.01 (.01)	.01 (.01)
Log (Planned Hours Per Second Plane)		−19.82* (4.60)	−9.47* (3.86)	−18.05* (4.12)	
Model Change		.05 (.12)	.01 (.11)	.16 (.11)	.25* (.12)
R^2	.89	.91	.96	.93	.92

Standard errors are in parentheses, with corrections for first order autocorrelation, and an asterisk indicates statistical significance at the 95% confidence level. The effect of overall IR factors in column (4) is the result after the log of planned hours per second plane is dropped.

The R^2 of the regression without industrial relations variables is .84. Adding all industrial relations variables increases the R^2 to .93. The partial F value is 13.10 which is statistically significant at the .05 level.

tautology. Some planes were assembled and delivered even during strikes. Especially during the protracted third strike, managers, engineers, and even economists were called upon to assemble planes for delivery. Although the effect of work-to-rule on labor productivity was smaller, that work action lasted more than 10 months. Work-to-rule had a large economic effect on productivity, costing the firm almost $21 million in lost productivity during the period, based on the estimates presented in the table.[15] This demonstrates the power of work-to-rule to impose heavy costs on the

[15]These estimates were derived by estimating the additional labor costs of the event: [(actual labor hours per month during the event) − (planned labor hours per month during that period) − (regression estimates of normal difference due to production factors)] * [(average number of pre-event planes delivered per month) * (average hourly wage for production employees) * (event length)].

Table 3. Impact of the Overall Industrial Relations (IR) Environment on the Log of the Difference between Actual and Planned Hours per Plane in the BP Plant, with Log of Capital per Person and without Lag of Dependent Variable as One Independent Variable.

Independent Variable	*Overall IR Factors without Non-IR Controls(1)*	*Leadership Related Factors (2)*	*Event Related Factors (3)*	*Overall IR Factors I (4)*	*Overall IR Factors II (5)*
Constant	8.82* (1.42)	−253.91 (286.2)	295.57 (152.88)	−154.12 (252.12)	275.75 (215.96)
Strike 1	.48* (.18)		.89* (.23)	.64* (.22)	.69* (.23)
Strike 2	.41* (.18)		.06 (.22)	−.13 (.21)	.19 (.20)
Strike 3	.33 (.18)		.03 (.22)	−.10 (.20)	.32 (.19)
Work to Rule	.20 (.18)		.57* (.20)	.41* (.19)	.50* (.20)
Union President 1	2.30* (.54)	2.49* (.55)		2.41* (.55)	2.20* (.57)
Union President 2	.95* (.47)	1.25* (.50)		1.11* (.49)	.92 (.51)
Union President 3	.34 (.41)	.14 (.42)		.19 (.41)	.38 (.43)
Union President 4	.38 (.34)	.07 (.34)		.15 (.34)	.33 (.35)
Union President 5	.41 (.25)	.39 (.23)		.40 (.23)	.45 (.24)
Total Quality Management Program	.08 (.18)		.16 (.17)	.18 (.16)	.14 (.17)
Manager 1	.09 (.41)	.01 (.41)		.07 (.40)	.21 (.42)
Manager 2	.09 (.34)	−.04 (.33)		.01 (.32)	.13 (.33)
Manager 3	.07 (.25)	.11 (.24)		.10 (.23)	.14 (.24)
Spantime		.00 (.00)	.00 (.00)	.01 (.00)	.00 (.00)
Log (Parts Shortage)		−.02 (.03)	.12* (.04)	.06 (.04)	.06 (.04)
Time Trend		−.01 (.03)	−.05 (.02)	.00 (.03)	−.05 (.03)
Log Learning Curve—Model 1		162.45* (52.30)	8.70 (36.59)	143.40* (54.76)	−44.78 (31.26)
Log Learning Curve Squared—Model 1		−5.78* (1.88)	−.28 (1.35)	−5.15* (1.96)	1.62 (1.14)
Log Learning Curve—Model 2		−7.27* (2.34)	−.25 (1.25)	−5.25* (2.13)	2.24 (1.19)
Log Learning Curve Squared—Model 2		.50* (.17)	.01 (.09)	.37* (.15)	−.17 (.09)
Planes Delivered per Month			−.00 (.00)	.00 (.00)	.00 (.00)
Log (Planned Hours per Second Plane)		−75.27* (14.86)	−30.32* (13.98)	−71.70* (17.02)	
Model Change		.28 (.26)	.22 (.27)	.27 (.26)	.21 (.27)
Log (Plant, Machinery and Equipment per Person)	.18 (.51)	.67 (.75)	.85 (.84)	.89 (.78)	.51 (.82)
R^2	.22	.37	.35	.42	.37

Standard errors are in parentheses, with corrections for first order autocorrelation, and an asterisk indicates statistical significance at the 95% confidence level. The effect of overall IR factors in column (4) is the result after log of planned hours per second plane is dropped.

The R^2 of the regression without industrial relations variables is .23. Adding all industrial relations variables increases the R^2 to .41. The partial F value is 3.78, which is statistically significant at the .05 level.

company at reduced risk and cost to the union. The negative productivity effect of work-to-rule was more than half as large as that of an overt strike.

Using the usual statistical conventions, we compare all other union leaders to the last one in our regressions. All the union leaders were associated with lower productivity in comparison to number six. Unlike the results of previous studies that have focused mainly on managerial effects on performance, our results suggest that union leadership also matters, and that not including the choice and policies of a union president may impart an upward bias to the measured influence of management on firm performance when unions are present (Leonard 1990; Murphy 1999).

Column (2) of Tables 2 and 3 shows the productivity impact of managerial and union leaders' policies, with controls for production-related variables and the time counter. The major industrial relations event during the period of our study was the TQM program with high levels of employee involvement. Our estimates of the effectiveness of the TQM program as implemented by BP suggest that it did not substantially influence productivity. An evaluation of this result should be tempered by the consideration that the TQM policy coincided almost perfectly with a period of heavy layoffs that many in the plant associated with the policy.

Managerial policies that were relatively lax with respect to employee discipline, represented by management leaders 1 through 3, reduced labor productivity. The reference manager, top manager number 4, used the toughest discipline within the firm. He virtually stopped the employee involvement program because he saw no significant initial productivity gains. He thought those policies delayed plane deliveries and damaged the firm's reputation with customers.

In column (3) of Tables 2 and 3, we show the effects of the industrial relations events with alternative controls in the two tables. Although there is some variability in the statistical significance of each variable based on the specification, they are, as a group, statistically significant at the 5% level using the F-test for the significance of all the industrial relations events. The Table 2 results are from an analysis that includes the lag log of the dependent variable and is a more rigorous test of statistical significance for the industrial relations event variables. These estimates show general consistency among the concerted activities, but no statistical effect of the TQM program in Tables 2 and 3.

Since both management and labor leadership and policies may influence productivity, we next develop an additional reduced form model that includes both sets of variables. In column (4) of Tables 2 and 3 we present a more fully specified model that includes the effects of both union and managerial leadership on labor productivity.[14] Care must be exercised in interpreting these results. Saying that union leader 4 was not such a negative factor (in terms of productivity) during the part of his term *not* spent leading Strike 3 or work-to-rule misses the obvious point that he did lead the local into Strike 3 and work-to-rule. It is important to bear this in mind, because we estimate the impact of leaders after controlling for the major industrial relations events of their terms.

To a surprising degree, the leaders can be distinguished from the policies in these data, at least in a statistical sense. The main results for the labor events, strikes and slowdowns, do not change greatly across specifications within Tables 2 and 3. Labor relations factors such as strikes and slowdowns generally have effects that are statistically significant and relatively large. For example, in column (4) of Table 2 the work-to-rule slowdown reduced productivity by 24% relative to expected productivity for more than a ten-month period.

Since including the planned rate of production for the second plane produced in the plant may bias downward the estimates of the industrial relations variables, in column (5) of Tables 2 and 3 we show our estimates with that variable omitted from the regression equation.[15] Column (4) shows that increasing planned production of the second plane is associated with fewer

[14]In estimating our time series models, we varied the timing of the events by one and two months to allow for the possibility that the firm adjusted, either anticipatorily or with a lag, to new managers, union leaders, strikes, or slowdowns, and found that our basic results were robust in spite of these changes in timing. These results are available from the authors.

[15]Since spantime and planes delivered could, in one sense, be perceived as endogenous with productivity, we estimated the model with these variables excluded from it and found basically the same qualitative results. With these variables deleted from the model, the industrial relations variable coefficients are higher. Our industrial relations results should be viewed as downwardly biased on productivity.

excess hours on the first plane, a surprising positive spillover. Omitting this variable (column 5) reduces estimated differences across managers, reduces the estimated learning curve, reduces the (negative) effect of TQM on productivity, and has a mixed, but generally small, effect on union leaders and strikes. Lifting the control for planned output on the second line, however, does not change our main findings.

The estimates in columns (4) and (5) of Tables 2 and 3 show that the statistical significance of the effect of union and managerial leadership diminishes somewhat when we control for all the industrial relations events in the production function. Generally the union leader effects on productivity are negative relative to the effects of the last union president, but the managerial leaders do not exert statistically significant effects on productivity. Consistent with our other results, the major managerial initiative during the period was the introduction of a TQM program, but this variable is imprecisely estimated in our model. In line with other studies of productivity in manufacturing, the production-related controls are generally consistent and statistically significant across all specifications, and the learning curve is robust. An F-test indicates that the industrial relations variables are jointly significant at the .05 confidence level.

It is surprising that the differences between the so-called "radical confrontational" union leader 4 and cooperative union leader 5 are not large in these estimates. Despite the vast gulf between the ideologies and rhetoric of these union leaders, productivity during their terms in office appears indistinguishable, apart from work-to-rule and the third strike. In other words, the cost to the company of a radical union leader was concentrated in the strike and slowdown he led. One could say the same for the benefits to the company of facing a union leader more focused on joint gains, except for the irony that the jointly led TQM effort had, if anything, the perverse outcome of reducing productivity.

A robust learning curve is also evident. The results in column (3) in Table 2 show that after assembly of approximately 65 planes, learning begins to reduce the number of hours per plane, and that there appear to be significant productivity gains over the production cycle as the number of planes assembled increases. This result contrasts with results reported in Benkard's (2000) study of the Lockheed L-1011 aircraft, which showed a sharp fall in output. The differing results could reflect the fact that the production run for the plane we examined (approximately 1,100) was more than five times that for the L-1011. They may also reflect our ability to more fully account for the factors that influenced labor's role and other institutional factors in the production of planes.

Just as some labor-management interpersonal relationships may sour, the attitudes of employees can, as a consequence of these poor interactions, turn hostile and result in poor performance. As we discussed in the production theory section, the personnel economics literature suggests that optimal matches would result in higher performance and that poor matches would result in a "demoralized" labor or management group, resulting in one of the leaders losing his or her position at the bargaining table and in the plant (Lazear 1995). To partially test this model, we categorize mutually exclusive union-management pairs over time, along with the control variables used in our previous estimates. Our results are shown in the Appendix. The omitted, or reference, group in this analysis is the toughest managerial leader (leader 4) paired with labor leader 6, a relatively militant leader who campaigned on the promise to do away with TQM. As we did in Tables 2 and 3, in columns (1) and (2) we drop the lag of the dependent variable and replace it with capital per worker. In columns (2) and (4) we drop the estimates of planned hours of production for the second plane produced in the plant to see if our initial results were biased downward.[16] Union-management

[16]We also estimated an ANOVA analysis. In these estimates we show how much of the total variation in

pairs of leaders during the earlier period were more likely to lower labor productivity than were the union-management pairs who were the toughest, and the latter occurred toward the end of our period of analysis. These results suggest that higher productivity is likely to occur when "hawks" negotiate among themselves (Lazear 1995), but we do not find a clear effect by rank order of tough versus more cooperative labor-management relations.

An alternative explanation is that the labor and management leaders' previous attempts at compromise and coexistence had resulted in few tangible outcomes, and that tough measures by both sides yielded few tangible gains, undercutting further efforts at cooperation, and provoking greater polarization. However noble the attempt, its failure to quickly bear fruit soured attitudes toward cooperation. At any rate, the interaction of labor and management pairs was a statistically important factor in productivity, consistent with the opinion expressed by Richard Freeman and James Medoff in the epigraph to this article.

From Traditional Labor-Management Practices to TQM and Back Again

TQM and related employee involvement programs are prominently featured in the managerial literature. This section develops a time-series auto-regressive model to examine the impact of TQM at BP.[17] We present an ARIMA-type time-series forecasting model of production. We use this model to project what the level of productivity would have been in the absence of the introduction of a TQM program. We next simulate the effect of the plant moving from a TQM program in December 1990 to a strict form of managerial monitoring (HM) of the work force and little to no employee involvement in plant-level labor relations.

Figure 2 gives the results of our counterfactual simulation. For the move to TQM from traditional labor-management relations, our results show that the firm lost money through reduced productivity by implementing the TQM program in 1989, but productivity increased during the second year the TQM program was in effect.

The overall impact of TQM was a slight reduction in labor productivity and an increase in production costs to the company for the total time period the policy was in place. This may reflect the way the company implemented the program, but given the large amounts of money and time spent on implementation, probably it was not due to lack of effort or emphasis placed on the TQM policies. Our discussions with management and labor leaders suggested that the failure of employee involvement was largely a result of top-down management. In addition, attempts were made by first-line supervisors to sabotage the TQM program for fear of losing control of the production stages they oversaw, and perhaps losing their jobs under this new program as employees made more decisions about production and team discipline. Any assessment of these indications that TQM was ineffective should be tempered by the consideration that the attempt to implement TQM occurred during a period of layoffs, and one condition for a successful program may be job security.

Another unique feature of the plant we studied was its switch from strong employee involvement practices to an authoritarian policy. The results in Figure 2 show that productivity increased and labor costs were reduced as a result of this more rigid form of management monitoring and control

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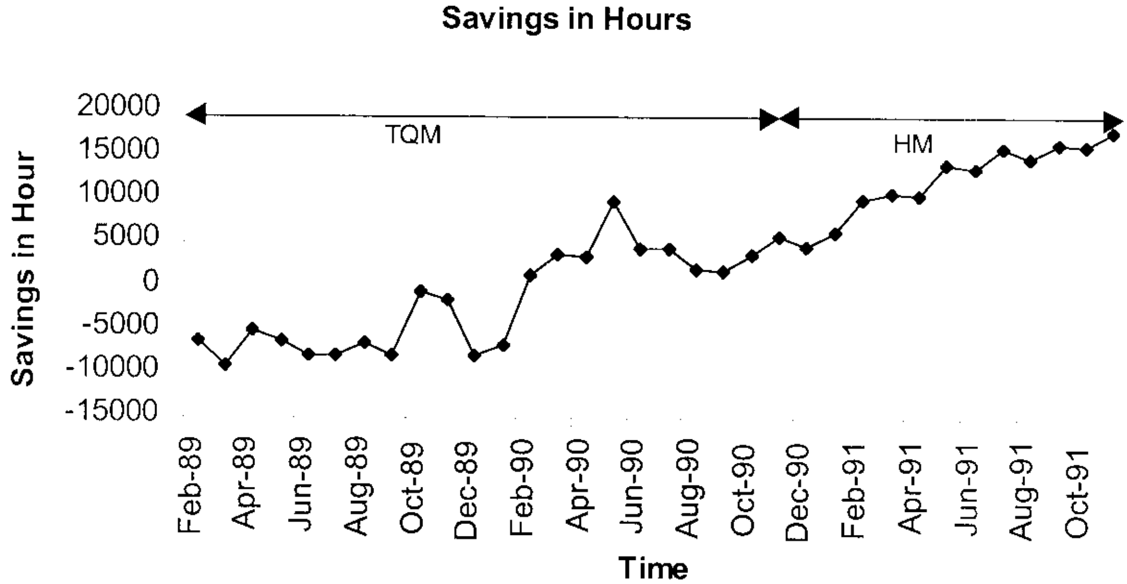
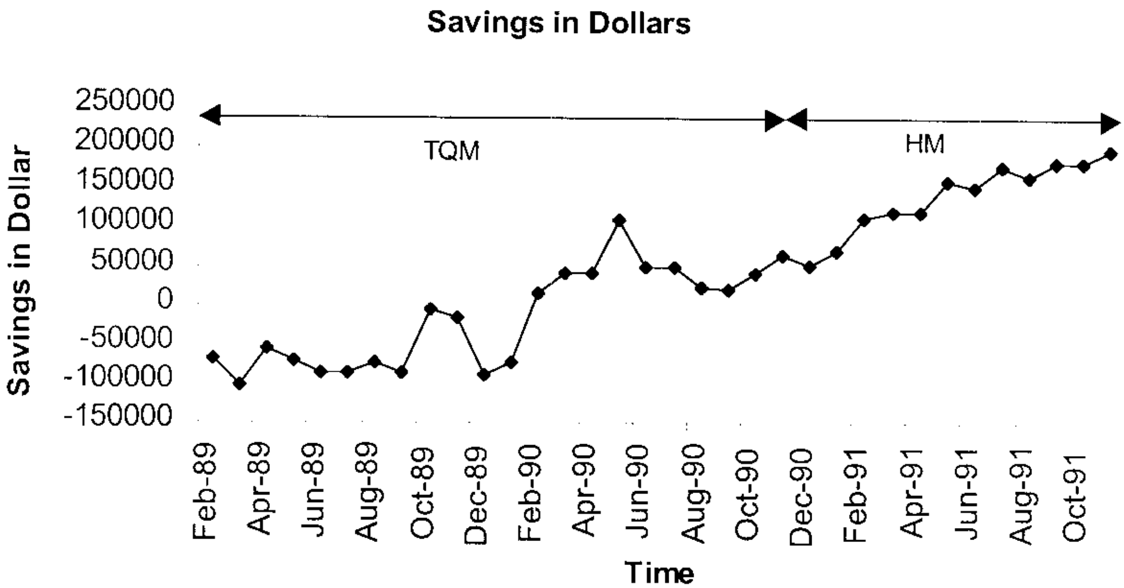
productivity is explained by strikes, work-to-rule, and union and company presidents. In all cases these industrial relations variables have statistically significant coefficients, and altogether they explain over half of the total variation in productivity over time. Earlier studies of aircraft manufacturing used only the learning curve as an explanatory variable. We find that omitting the role of industrial relations events and actors may impart substantial omitted variable bias to the resultant manufacturing productivity results.

[17] Our estimates of the ARIMA-type model were of the following form for January 1974 to February 1988, one month prior to the start of the TQM program: $\text{Lcost} = b_1 + b_2 \text{Lcost}_{(-1)} + b_3 e_{(-1)} + e$, where Lcost is the monthly standardized hours per plane. We then used this model to forecast labor costs for the period February 1989 through November 1991.

Figure 2. Estimated Counterfactual Effects of the Impact of Total Quality Management (TQM) on Hours and Dollars per Plane in BP Relative to NO TQM and Heavy Monitoring(HM)





Note:
1. TQM was in effect from Feb. 1989 to Nov. 1990.
2. Total estimated effect of TQM was -33,838 hours and $-367,283 savings.
3. Total estimated effect of moving from TQM to heavy monitoring (HM) was 151,322 hours and $1,682,698 savings.

Table 4. Impact of Industrial Relations Events: Number of Months for Productivity Levels to Return to Pre–Industrial Relations Event Values.

Industrial Relation Event	*Months to Return to within 1% of Pre-Event Productivity*	*Months to Return to within 5% of Pre-Event Productivity*
Strike 1	1	1
Strike 2	3	3
Strike 3	4	3
Work to Rule	1	1
TQM	1	1

Note: the pre-event productivity level is the predicted productivity level using the regression model estimated in Table 4, excluding the actual event.

for a one-year period. Unfortunately, we do not have estimates of what would have happened to productivity had the plant managers established a more moderate control regime, that is, keeping some elements of employee involvement but increasing the level of direct monitoring and discipline. We are able to find some evidence on the symmetry of the impact of moving to TQM with employee involvement and returning to more adversarial labor-management relationships. Given the labor relations culture in this plant, which fostered more traditional adversarial relationships, the move to employee involvement was difficult. Perhaps the plant should have maintained the program, since it was showing positive results in its second year of operation. Nevertheless, our results provide some evidence for why firms may choose not to adopt a "high-performance workplace." These programs are costly and disruptive to implement. In large older establishments, their immediate impact may be, as here, to reduce labor productivity and disrupt delivery schedules. At best, TQM with employee involvement should be seen as an investment in the future.

Long-Term and Comparative Effects of These Industrial Relations Events

In Table 4 we simulate, using our regression model, how long following strikes, slowdowns, and the TQM program it took for the plant to return to the pre-event standardized hours per plane per month. To assess these changes, we use two different measures. In columns (1) and (2) of Table 4 we estimate how long it took for plant-level productivity to return to the trend line predicted by the regression model in Table 2, excluding the event that is being forecast. This table shows how many months it took for the plant to return to within 1% and 5% of its pre-event productivity levels, measured by standardized hours per plane. For example, the second row of the table shows that for the second strike in our data sample, it took the same length of time—three months—for the plant to return to within 1% and 5% of its pre-strike productivity. For the other events it took about the same time for organizational labor productivity to return to within 1% and 5% of the pre-event levels of average output. This value ranged from one to four months, which is not long as judged by any standard metric.

The most divisive strike, number three, was also the longest, and in its aftermath, not surprisingly, the plant took between three and four months to return to pre-strike levels of productivity. The damage inflicted by this strike persisted for months after the strike formally ended.

The work-to-rule event served as a substitute for a strike. However, even with this relatively long process of intentional reductions in productivity, it took the employees only one month to reach about the average of the pre-slowdown levels of output. Finally, the TQM period, with attempts at heavy levels of employee involvement, resulted in reduced productivity for the first year it was in operation. However, after the two-year program ended, the plant achieved pre-TQM levels of output within one month. Overall, it appears that for this plant, strikes, work-to-rule slowdowns, and TQM programs have short-lived effects. Although industrial relations events are dramatic and elicit great emotional outpourings from both labor and management during and shortly after their occurrence, the long-run effects are fairly minor as measured by labor hours per plane.

Although we show that concerted activities like strikes and slowdowns have limited long-term effects on productivity, they are certain to have strong effects on short-term profits. The union in this case did impose appreciable costs on the plant managers and shareholders in the short run. However, after the strike or slowdown, the production employees did not "forget" what they knew about manufacturing, and they were able to return to previous levels of production after a relatively short period. One might be concerned that a strike leaves long and bitter memories. Whatever animosity the strikes at BP created, they did not prevent workers from quickly reaching pre-event levels of productivity.

In Table 5 we compare the costs of the four concerted activities during the period of our study by estimating, for each one, the difference between actual monthly dollar labor costs and planned labor costs, and subtracting from that result the *usual* monthly difference between planned and actual labor costs. The latter is estimated by a separate regression that uses only union and production variables, as in Table 2, multiplied by the number of planes that would have been delivered if the production rate had matched its average value over the period between five and two months prior to the event.[18] The estimates show that even though strikes may have had a more immediate negative productivity effect than did work-to-rule, the latter had a larger negative economic effect in terms of total lost productivity. For example, the work-to-rule policy increased labor costs almost 48% more than Strike 3. The protracted work-to-rule policy by the union imposed greater costs on management than did any of the strikes, with little direct economic loss to the local UAW membership.

Table 5. Impact of Industrial Relations Events: Costs of Concerted Event to BP Relative to Planned Productivity.

Industrial Relations Event	*Dollar Cost*
Strike 1	$2,666,366
Strike 2	$835,057
Strike 3	$14,123,754
Work to Rule	$20,859,686

Note: additional labor costs of the event = [(actual labor hours per month − planned labor hours per month of the event) − (regression estimates of average deviations estimated from an equation including production and union variables as in Table 2) × (average number of pre-event planes delivered per month × average hourly wage × length of the event)].

Conclusions

Industrial relations events substantially change productivity. We have examined a major firm in an oligopolistic industry that is the largest manufacturing exporter, and second largest manufacturing employer, in the United States. We combine a time-series statistical analysis of 18 years of monthly production data with in-depth interviews with the leading industrial relations "actors" in this plant. The statistical analysis provides a quantitative foundation for the interviews. By confining our analysis to one plant that produces a fairly standardized product, we are able to minimize unobserved heterogeneity in production.

Strikes, slowdowns, and union leaders influenced the productivity of this plant by large percentages and large absolute dollar amounts. Our findings are unique in show-

[18]The OLS regression equation included union leaders, industrial relations variables, learning curve, learning curve squared, parts shortages, delivered planes per month, second plane planned costs, spantime, and a time trend. Estimates of the equations are available from the authors.

ing that omitting factors such as union leadership and labor relations events may result in a mis-specified equation when researchers analyze firm performance.

The major managerial innovation, TQM, did little or nothing to increase productivity over the short time it was in place. In the short term, its effects were perverse. It reduced labor productivity slightly and increased labor costs. Ironically, TQM had finally begun to show positive effects during its second year, just as management's patience ran out and it abandoned the program. How and why TQM is adopted may be just as important as whether it is adopted. Like many firms forced by difficult circumstances into change, this firm did not enjoy the luxury of a lengthy stress-free course of treatment.

Another unique part of this study is our measurement of effects of the movement from traditional management to TQM with employee involvement and back again. The movement from TQM to an authoritarian mode of management showed positive productivity effects in the short run. We hope to gather more data from this plant to examine the long-term effects of greater discipline and closer monitoring of the production work force as the organization moved further away from TQM practices.

Finally, our results show that major industrial relations events like strikes, slowdowns, and the TQM program did not have long-term productivity effects, and that the firm we studied was able to return to pre-event levels of production within one to four months. An implication of our analysis for the firm performance literature is that studies that omit the role of union leadership, where labor organizations are present, may overstate the role of management. Furthermore, our results show that the positive effects of movement to higher-involvement human resource polices may also be upwardly biased because they fail to account for the impact of firms that try without success to implement "high-performance" workplace practices.

Finally, studies of manufacturing productivity that estimate learning curves but fail to include industrial relations factors may suffer from omitted variable bias and thus overstate the effect of the learning curve and other production processes. Analysis of one plant cannot fully address all the ways in which union and management policies and practices affect productivity. Our results in part reflect the unique characteristics and corporate culture of this establishment. Yet our study does show that combining interviews with statistical analysis can add both depth and rigor to the analysis of the effects of industrial relations on organizational performance.

APPENDIX

Impact of the Union/Management Leadership Pairs on the Log of the Difference between Actual and Planned Hours

Independent Variable	*Overall IR Factors without Lag of Dependent Variable as One Independent Variable (1)*	*Overall IR Factors without Other Outputs and Lag of Dependent Variable as One Independent Variable (2)*	*Overall IR Factors (3)*	*Overall IR Factors without Other Outputs (4)*
Constant	−154.12 (252.12)	275.75 (215.96)	84.69 (53.15)	−28.90 (50.76)
Strike 1	.64* (.22)	.69* (.23)	.41* (.19)	.56* (.19)
Strike 2	−.13 (.21)	.19 (.20)	.38* (.18)	.32 (.18)
Strike 3	−.10 (.20)	.32 (.19)	.51* (.17)	.39* (.16)
Work to Rule	.41* (.19)	.50* (.20)	.24* (.10)	.26* (.11)
Manager 1–Union President 1	2.48* (.67)	2.41* (.69)	2.07* (.35)	1.65* (.35)
Manager 1–Union President 2	1.18 (.63)	1.13 (.65)	1.14* (.31)	.74* (.32)
Manager 1–Union President 3	.26 (.56)	.59 (.57)	.87* (.26)	.73* (.27)
Manager 2–Union President 3	.20 (.51)	.50 (.52)	.84* (.27)	.70* (.28)
Manager 2–Union President 4	.16 (.45)	.45 (.46)	.86* (.20)	.71* (.20)
Manager 2–Union President 5	.41 (.37)	.58 (.38)	.74* (.16)	.49* (.16)
Manager 3–Union President 5	.50 (.31)	.59 (.31)	.50* (.16)	.43* (.17)
Manager 3–Union President 6	.10 (.23)	.14 (.24)	.16 (.16)	.12 (.17)
Total Quality Management Program	.18 (.16)	.14 (.17)	.15 (.13)	.01 (.13)
Spantime	.01 (.00)	.00 (.00)	−.00 (.00)	−.00 (.00)
Log (Parts Shortage)	.06 (.04)	.06 (.04)	.07* (.02)	.09* (.02)
Time Trend	−.00 (.03)	−.05 (.03)	.01 (.01)	−.01 (.01)
Log Learning Curve—Model 1	143.40* (53.76)	−41.78 (31.26)	18.72* (7.97)	3.37 (7.54)
Log Learning Curve Squared—Model 1	−5.15* (1.96)	1.62 (1.14)	−.68* (.30)	−.09 (.28)
Log Learning Curve—Model 2	−5.25* (2.13)	2.24 (1.19)	−.08 (.17)	.06 (.18)
Log Learning Curve Squared—Model 2	.37* (.15)	−.17 (.09)	.00 (.01)	−.01 (.01)
Lag of the Dependent Variable	—	—	.64* (.05)	.69* (.05)
Log (Plant, Machinery and Equipment per Person)	.89 (.78)	.51 (.82)	—	—
Log (Planned Hours per Second Plane)	−71.74* (16.78)	—	−18.05* (4.11)	—
Model Change	.27 (.26)	.21 (.27)	.16 (.11)	.25 (.12)
Planes Delivered per Month	.00 (.00)	.00 (.00)	.01 (.01)	.01 (.01)
R^2	.93	.37	.93	.92

Notes: Standard errors are in parentheses, with corrections for first order autocorrelation. Asterisks indicate statistical significance at the 95% confidence level.

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