NBER WORKING PAPER SERIES

DO INDUSTRIAL RELATIONS AFFECT PLANT PERFORMANCE?: THE CASE OF COMMERCIAL AIRCRAFT MANUFACTURING

Morris M. Kleiner
Jonathan S. Leonard
Adam M. Pilarski

Working Paper 7414
http://www.nber.org/papers/w7414

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
November 1999

This study was supported by a grant from the Alfred P. Sloan Foundation. The authors thank Neil Chaffee, Sandy Donovan, Adrienne Howard, Yongjin Nho, Yonglin Ren, Keith Vargo, and Donghoon Yang for their assistance with this study, as well as comments from participants at seminars at the University of Minnesota and the NBER. The views expressed herein are those of the authors and not necessarily those of the National Bureau of Economic Research.

Do Industrial Relations Affect Plant Performance? :
The Case of Commercial Aircraft Manufacturing

Morris M. Kleiner, Jonathan S. Leonard, and Adam M. Pilarski

NBER Working Paper No. 7414
November 1999
JEL No. J5, J3, L2

ABSTRACT

This study analyzes the impact of major industrial relations variables on productivity within a plant that assembles large commercial aircraft. The analysis combines the deep firm-specific knowledge of management and labor typical of the best of traditional industrial relations with formal statistical tests. We use a before and after research design over an 18-year period with monthly data, as well as information from the participants in the industrial relations events. Our approach is unusual in showing that by focusing only on managerial factors or the learning curve, and omitting factors such as union leadership and related labor relations events, estimates may mis-specify impacts on firm performance. Strikes, slowdowns, and tough union leaders influenced the productivity of this plant by both large percentages and absolute dollar amounts during the period they were occurring. In contrast with much of the firm performance literature, we find small initial productivity impacts of movements 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 may be just as important as whether it is adopted. Finally, simulations from a counterfactual case 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 returned to pre-event levels of production within one to four months.

Morris M. Kleiner
Humphrey Institute of Public Affairs
and Industrial Relations Center
University of Minnesota
Minneapolis, Mn. 55455
and NBER
mkleiner@hhh.umn.edu

Jonathan S. Leonard
Walter A. Hass Graduate School
School of Business
University of California, Berkeley
Berkeley, Ca. 94720
leonard@haas.berkeley.edu

Adam M. Pilarski
AVITAS,DNV
1835 Alexander
Bell Drive, Suite 200
Reston, Va.20191
gurudude@avitas.com

"unionism per se is neither a plus nor a minus to productivity. What matters is how unions and management interact at the workplace." (Freeman and Medoff, *What Do Unions Do?*, 1984)

I. Introduction

To what extent do industrial relations policies and practices, including the interactions of labor leaders with top- level managers, influence labor productivity? Do total quality management programs that include strong elements of employee involvement affect organizational performance? Does overt conflict or cooperation in labor management relations such as strikes, slowdowns, or employee involvement influence the short or long- term efficiency of an enterprise?

This study attempts to combine the deep firm-specific knowledge of management and labor typical of the best of traditional industrial relations, with formal statistical tests to gain insight into these fundamental questions. 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. We observe production of a fairly uniform product in this plant over an 18 year period in which its employee relations changed dramatically and spanned the range from mature cooperation to open conflict, from employee involvement to radicalized polarization. The combination of a wide range of industrial relations policies with detailed production records on a stable product give us a opportune setting to examine the impact of management and union relations on productivity.

The aircraft industry is of particular importance because it has been one of the dominant export sectors 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 U.S. behind only automobile manufacturing. The sector is characterized by huge investments in capital, substantial research and development, and long product development periods that sometimes exceed a decade from the research and development stage to the roll- out of the final product. Also, the product cycle is long, frequently exceeding 20 years. The assembly of the final product, which is the primary contribution of the firm, includes elements of mass production and of a customized product. Although the assembly process is similar across planes, each section of the commercial aircraft has unique elements specific to the final customer. Labor costs as a percentage of total value added is low, but hourly earnings of production workers are about 40% above the average wage in manufacturing and the firm employs a substantial number of scientists and engineers (Kleiner, Nickelsburg, and Pilarski, 1995). During the past decade the industry in the U.S. has faced increasing competition from European producers in the form of Airbus, a multinational organization that has been able to obtain the kind of dynamically increasing returns in manufacturing assembly to be internationally competitive with high value added, a capital intensive infrastructure, and a rapidly decreasing learning curve.

One of the main reasons that the U.S. is able to maintain its competitive advantage is its high levels of factor market competitiveness including managerial talent and policies, and the productivity of its production workforce (NRC, 1985). From the perspective of developing production analysis, the industry has been the subject of one of the first economic analyses of the learning curve, which was developed with applications to commercial aircraft production and was then modeled more generally for other industries (Asher, 1956, and Arrow, 1962). More

recent estimates of the learning curve have shown generally improved learning in production assembly with some modifications to the trend to account for what has been labeled "organizational forgetting" (Benkard, 1999).

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). But this 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. 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 that of confrontation to one of cooperation.

A main goal of this paper is to examine the role of management, labor, and their joint policies and practices on the labor productivity of large commercial aircraft. Initially, we examine industrial relations practices within the theoretical context of production efficiency, with a focus on aircraft assembly. We also sketch out theory on matching union and managerial leaders in production that are consistent with our observations within the company. Next, we present the data obtained directly from the monthly company data files that we employed to investigate these relationships. A major commercial aircraft manufacturer agreed to give us information from the organization's main management information system data base, under the condition that we do not use its name in our publication. Consequently, we will call the

company Big Plane or BP. One advantage of our data relative to information gathered from surveys is that we would expect it to be more accurate and detailed than, for example, survey information employed from the Census of Manufacturing LRD file. In general, firms have a greater incentive to check the quality of internal data, since it is gathered at considerable cost to the firm and is used for making policies within the organization as well as for developing corporate strategies. Another unique aspect of our study is the opportunity to examine the impact of industrial relations within the firm by reducing unobserved heterogeneity in production, an issue that has plagued other studies that use many industries or plants with differing capital and labor requirements. We do this by examining one plant that produces the same standardized product with largely the same workforce and virtually the same technology over a relatively long period of time. We follow this discussion with an examination of the unique 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. As part of this discussion we focus on both the leaders of the union and management and their interaction in producing industrial relations events that affected productivity in the plant. Finally, we empirically assess the effects of industrial relations factors on production using both traditional time series regressions, multivariate statistical approaches, and a counterfactual simulation that assesses the effect of a total quality management program as well as other important labor- management events (Freeman and Kleiner, 1998).

II. Industrial Relations Events and Productivity

Most previous 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 they 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 impacts of these variables are biased downward, whereas the direct effects of these events are likely to be much larger if they are directly measured at the level of the establishment. In this section we examine the effect of highly visible industrial relations conflicts such as strikes and work slowdowns on the firm. In addition, we explore the effects of top management and labor leaders on productivity within this large airplane assembly plant. Since labor inputs are a substantial cost item in commercial airplane production, we anticipate that changes in the industrial relations climate and organization of work in the assembly line would affect the productivity of the organization. In the context of a production function, changes in the policies and practices that affect the organization of work would result in changes in productivity.

We enrich a production function to allow for the possible effects of labor policies and practices. 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 x H x S

where N is the number of workers, H is the number of hours, and S is the intensity or the effort

of the workers. The industrial relations environment is assumed to influence N, H, and S so that production by substitution of equation two into one yields

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

In this case the industrial relations environment will influence the level of output through L by changing the number of production workers and the hours of work(H), and reallocating workers among tasks, as well as changing the intensity of effort (S) that workers are willing to put forth in production (Kleiner, Nickelsburg, and Pilarski, 1995). This specification explicitly takes into account how labor and industrial relations influence the production function, a role that has been ignored in other studies of manufacturing production.

A. Union and Management Pairs

In any employment relationship, there is continual tension between a joint management-labor interest in expanding the pie, and conflicting interests in the division of the pie. We expect some productivity impact from the management and union leaders who are primarily responsible for the organization of work within the plant. This would include hiring the workers, motivating effort, and choosing the number of hours for production employees. We do not present a formal theory but rather sketch the basic ideas from the personnel economics literature that there are labor/management leadership pairs that are better suited to productivity gains than others, and then we use our plant-specific case study as an example. In general, the union leader's objective is to achieve wage gains and employment security for the membership that are largely derived from the benefits of productivity growth. For the management leader the objective is assumed to

be profit maximization with productivity gains a key element in that objective[1] In our case example there were bargaining pairs that resulted from both the firm and the employees choosing leaders and shop stewards partially in response to the leadership characteristics of the other party, and 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. Agency issues may arise regarding the role of the plant to other corporate objectives and the relative performance of this plant in comparison to others. This union local has been extremely democratic, with organized political factions competing for leadership positions on the basis of distinct ideologies of cooperation or conflict with management. Local union leaders not only can lose a re-election bid, but they have changed policies in response to the perceptions and goals of their members, which also varied

---

[1]Bad matches may form because of either imperfect information on both sides or the methods of achieving the objectives of both sides are not compatible (Devine and Kiefer, 1991). At any point in time a union leader is assumed to be matched with a given manager, where each knows the characteristics of the other. Each residual claimant, shareholders or union members, respond by choosing someone who can best attain their goals over the contract period. For our purposes we define a labor/management leadership pair as

(4) $P_i=f(U_L + M_L)$

where $0< U_L \leq 1$ and $0<M_L \leq 1$, where U is the union leadership and M is the management leadership that form the characteristics of the matched pair P.

[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_i, conditioned on the productivity level can be written as

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

where $F_i(*)$ denotes the time *t* estimate for the productivity distribution for the current pair P_i and α denotes the receipt rate of productivity observations. Although productivity is a constant in (5), 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 from management's perspective to satisfy shareholders, and from the union view, the wage rate and employment security is expected to grow from any productivity gain which then satisfies the membership. Generally the d from the union side would come at a regularly scheduled election, whereas managers can be replaced at any time.

over time (Freeman and Rogers, 1999). The local union was also responsive to the international UAW's concerns and during one period operated under the supervision of the UAW because the international was dissatisfied with the performance of the local.

In addition to the duration of time for any union/management pair there are often questions about the type of managers and union leaders that may lead to optimal productivity. Edward Lazear provides some theoretical insights suggesting that a relationship between two tough leaders, or "hawks," may provide an environment of greater productivity than would a tough leader dealing with a weak one, or "dove" (Lazear, 1995). For example, production employees may reduce their effort if they think that a tough manager who is concerned mainly with short- term profit maximization will be likely to reallocate more of their efforts toward profits and away from wages because a weak union leader is unwilling to use their leverage. The extent to which union and management negotiators are viewed as tough or conciliatory can provide some insights into the productivity effects of alternative matches of labor management negotiators and leaders within an organization. Although we cannot formally or rigorously test for the existence or optimal timing of a particular match of leaders relative to a random draw, we can provide some insights into how particular pairs of union and management leaders may enhance productivity relative to others, and how this may be consistent with theoretical insights gained from the personnel economics literature.

B. Our Quantitative and Qualitative Data on Production

Estimates derived for the role of industrial relations outcomes on production come from internal company plant level data obtained from one of the largest manufacturers of large commercial aircraft, the firm BP, which is generally representative of the trends in the industry.

In Figure 1, panels A through C, we show the annual economic characteristics of the BP firm's commercial operations relative to the other U.S. firms in the industry beginning in 1974, the starting date of our other empirical analysis, through 1991. The table shows that BP grew about as fast as the other major firms in the industry as measured by commercial revenue, overall employment, and planes delivered, with some deterioration after 1983. This Figure shows the cyclical nature of this industry which affected BP and its competitors and may have influenced the nature of its industrial relations practices. For most of the period of our study, BP accounted for between 25 and 30 percent of total industry output, employment, and revenues and the firm appears to be representative of the other economic changes that occurred in the industry.

As part of the information compiled by BP, they gave us their monthly productivity data on the production and assembly of their main commercial aircrafts in its principal plant from January 1974 through November 1991 for a total of 215 monthly observations on production. Our key data is for the same general model of plane as well as some information on the planned rate of monthly production for its companion aircraft, both of which were produced throughout the period in one large plant. In 1980 there was a redesign and update of the basic model that caused major changes in productivity as workers learned the new production processes necessary for this updated model of the same plane. As discussed, the plant-level information over this 18-year period was gathered for 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 in the plant 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. 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 views about cooperation versus confrontation with management in the plant. For example, different union leaders' attitudes ranged from adopting total quality management with high levels of employee involvement to seeking a confrontation with management over work issues. One union president called for crude class warfare on most issues in an effort to reallocate plant and company level "rents" toward labor. If cooperation enhances productivity and confrontation reduces it, then having measures of union leadership policies and practices, as a proxy for members preferences, should give us a proxy measure of the attitudes of the employees. They certainly tell us which union leadership styles attracted majority support in internal election contests.

Capital per production worker remained nearly constant in the production of this plane and its larger companion version that was produced in the plant. Learning by employees about the assembly of the plane was the only major innovation in the production process. Our measure of productivity is the difference between actual and planned labor input per plane. This specification allows us to difference 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 standardized number of person hours per plane, as defined by the production quality control persons in the plant.[3] To control for other factors known by management to affect productivity but which we could not directly observe, we use management's planned labor input per plane. This value is what the production managers presumed would be the expected production level or planned production. These planned production values were estimated with known capital and labor available within the firm and projected demand for the planes well in advance of actual outcomes (about two years prior to the actual production level). The estimates were developed using the learning curve in production and assumed there would be no parts shortages or labor relations strife, with the forecasters not knowing who might be the labor or management leader in the future. The forecasters also assumed continuation of the existing production rate. In many ways the planned rate can be viewed as output under the best possible conditions, and we would expect that it would lie below the actual level of labor productivity.

The other key variables we used to control for production related factors were span time, 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 produced in the same factory, and the number of planes delivered and accepted by customers per month. This detailed data is similar to other firm level analysis obtained in a study of the auto industry (Ruff, 1996).

Span time measures the average workdays from start to finish for the assembly of each plane and is used to control for either fast or slack periods within the plant that may influence the

---

[3]This value was calculated as the full time employee equivalent number of production hours that was assigned to each plane by first-line supervisors and audited by the quality control managers in the plant.

pace of production. When production was sped up, it affected both learning in production and increased the number of parts shortages during any monthly production period. When there were parts shortages, the assembly line was substantially reduced or stopped. As a consequence, learning in production was reduced, and there were obvious delays in the production process. This value was measured by the number of parts, and we assumed that this variable would have a strong effect on labor productivity for airplane assembly. In order to maintain as long a time-series data series and 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 any estimated results in our regressions (Little and Rubin, 1987).[4] Since the plant we examined had two major lines of aircraft being assembled, we used the anticipated numbers of hours of the other assembly process as a control for the demand for hours and material resources in the organization and as cross product demand in the production function. This variable may also reflect organizational priorities in production for the product.

Other estimates of labor productivity that have examined large expensive outputs, like studies of commercial ships, have had relatively few clear-cut measures of the quality of the final product (Thompson, 1999). In the case of large commercial aircraft there are many rigorous quality controls on the final product. For example, test pilots from the company must test the aircraft by flying it through rough weather. In addition, the Federal Aviation Administration engages in several rigorous tests to certify the quality of the final product. Finally, the customer

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

must accept the delivery of the plane, for which it has paid many millions of dollars. Overall the final product is a standardized unit over time in which high quality standards are applied and certified through a number of tough independent tests.

C. Labor and Management Relations in Production

In addition to the production data for BP, we also have monthly data on many of the labor relations aspects of the employment relationship. There were more than 22,000 members of the local union who worked in the plant complex in 1992, and this local had the largest membership of any plant local in the United Automobile Workers (UAW) in the U.S. and Canada. This BP plant experienced a wide array of industrial relations events and conditions during the 1970s through the early 1990s. For example, there were three strikes and a work to rule slowdown as a substitute for a strike during stalled negotiations.

The two competitive political parties with organized slates and contrasting ideologies vied for control of the local union. One was generally more cooperative in its stance toward management while the other took a more confrontational approach. Given the highly democratic and competitive nature of various parties within the local union there were six different union presidents over the period we examine, which reflected the memberships' varying attitudes toward labor's cooperation with managerial policies. Union leader four was the most militant in his campaign for the union presidency, and was also the leader during the longest strike. In contrast, leader five was elected as a reaction to his predecessor, and followed the most cooperative approach toward management. Unfortunately for five, the cooperative approach was associated in the minds of the membership with layoffs and concessions to management. Consequently, a militant union leader was elected for the last two years of our period of

analysis. For each of the industrial relations variables, we know the beginning and ending month in which the events occurred and the general policy directions of the union leader. This institutional knowledge allows us to use a before and after experimental research design as well as more structurally oriented simulations.

It is fundamental to understand how union-management relations affect firm performance. Although other studies have attempted to examine the relationship of union leaders to industry productivity, we were unable to find any analysis of this issue at the firm level (Navarro, 1983, and Freeman and Medoff, 1984). The elected union leaders in the plant in our study reflected a diverse set of goals regarding the union's relationship with management. As background, this union local is perceived to be among the most politically competitive of all UAW locals, with no union president holding office longer than seven years during the past thirty-five years. The political parties campaigned vigorously and explicitly stated their views of the appropriate levels of militancy toward management.

During the early period of our analysis the union leadership reflected traditional adversarial labor management relations. Union leaders one through three were relatively moderate in their bargaining styles and viewed strikes and other concerted activities as acceptable only as a last resort method in obtaining concessions from management on wages, hours, and other conditions of employment. Union leader four campaigned on a platform of confrontation with management and was the most militant leader out of the six during the period of the study. He led the union and its membership through the longest strike in the history of the plant in 1983. 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 were also rocky during his term in office. Toward the end of union leader four's leadership the international UAW declared the union to be in "receivership" because of poor management and loose financial controls, and the international office greatly increased its monitoring of the local organization.

Another concern from the international union's perspective was the tough and usually mean- spirited election campaigns that occurred within the local and their independence from international UAW's policies and practices. For example, union leader five was supported by the international UAW and had tacit support from management. He was elected during 1987, and took over following highly acrimonious labor relations that included a three-month strike, an in plant slowdown, and financial troubles that the local had with both the international UAW and the AFL-CIO. Five campaigned on a promise to work closely with management and to establish a total quality management (TQM) program that included high levels of employee involvement. He attended several national training sessions on employee involvement, and was committed to having the local union participate in the process. A decline in orders, layoffs, internal union problems, and first-line supervisors' opposition to TQM led to union leader five being replaced, although he later won reelection during the mid 1990s.

Union president six was a more militant leader, who was elected following the "failure" of employee involvement within the plant. He campaigned on a pledge that he would pull union support out of any TQM program, and he followed through on that campaign promise following his election in 1990. 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 wages.

There were three strikes during the period of our study that lasted from one to three months.[5] The last one in 1983, included threats by workers to destroy plant equipment as well as threats from management to replace production workers if a quick solution to the impasse was not reached. During this strike the union settled for the same basic contract that was offered by management prior to the work stoppage. Prior to the last labor agreement in our sample, there was an in- plant slowdown that lasted almost 11 months as a tactic to pressure management without a strike that would cost union workers wages and potentially even their jobs. This tactic included traditional work to rule procedures, where the production workers strictly followed the letter of the previous contract, and refused non- mandated overtime work as well as other job assignments that were not explicitly stated in the labor contract. Given the costly effects of the previous strike at the plant to employees, the unionists thought that they could impose costs, through lower short term productivity, without losing a paycheck.

D. Managerial Policies' Impact on Plant Performance

Managerial policies and practices also changed dramatically during the period we analyze. The BP company is traded on the New York Stock Exchange and was not involved in any significant mergers or acquisitions from the 1970s through the early 1990s. The industry is highly volatile, and cyclical, and contains large elements of both civilian and military production. One of the military production facilities operated by BP is located near the civilian aircraft factory. During the study period, the plant was led in succession by four presidents of

---

[5] 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.

commercial aircraft manufacturing, who were primarily responsible for industrial relations. The major managerial innovation was the implementation of a total quality management (TQM) program within the plant, which was a top-down approach since the president of the company mandated the policy in an effort to become a "high performance workplace"(Ichniowski, Shaw, and Prennushi, 1997). This policy was supposed to help the plant become more productive in an effort to deal with the threat of new foreign competition. As part of this program the company spent about $53 million in direct training costs over a two-year period and the firm hired a new vice-president of quality, with considerable experience in "Japanese style management," to implement the program. First line supervisors surmised that their jobs were in jeopardy if total quality management program with teams that had greater autonomy succeeded. As part of the TQM program a major objective of the firm was to drive grievances by employees to zero, with the vice-president receiving a substantial bonus if formal worker complaints were below a certain level. Further, we obtained the monthly beginning and ending dates of the president of the commercial aircraft manufacturing division, who was directly in charge of industrial relations policy. Division presidents were chosen or remained on the job in large part based on their success in increasing productivity.

The first company president's industrial relations policies followed the traditional adversarial behavior of labor and management in this plant. More specially, 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 and throughout the industry during the post World War II period (Walton and McKersie, 1991). Monitoring of the workforce was relatively rigid with abusive language and reprimands of the

employees in front of other workers employed by top level management and other supervisors at various times. The second company president oversaw a gradual movement to quality circles, the forerunner of employee involvement in the plant, following a long and difficult strike during which management threatened to hire replacement workers. The third company president implemented the TQM program in large part as a result of a directive from the CEO of the parent company. A new vice president of quality was recruited to come to BP, because of his managerial background at an auto manufacturer with high involvement work teams. Company rules and regulations were relaxed and negotiations with the union took on a more cooperative tone. The final company president was the toughest disciplinarian, and he used policies and practices that were in direct opposition to manager three. He thought that the TQM approach had resulted in a decrease in productivity, and an increase in labor costs in the production process, as well as a delay in meeting deadlines with customers for the delivery of airplanes. Consequently, company president four engaged in strict monitoring that some in the plant referred to as a "boot camp" type of management. Monitoring of production employees was tight, and discipline and grievances within the plant increased dramatically. This last manager is the base group for our statistical analysis, and productivity performance during his tenure will be used as the comparison grouping relative to the other company presidents.

E. 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 document that both management and union leadership at various times swung from one end to the other of the cooperation-conflict spectrum.

These extreme swings in industrial relations policy 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. In Figure 2 we show the timing of the major industrial relations events that we have described including major union and management leaders, strikes, slowdowns, model changes, and the implementation of total quality management (that included elements of employee involvement) superimposed on productivity measured by standardized hours per plane per month. To assess these changes, we use two different strategies. First, where possible, we use time-series regressions to estimate the effect of the principal changes in 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.[6] In these OLS regressions, we include a monthly time trend, the lagged log of the dependent variable, the learning curve, the number of delivered planes per month, the time measured in days from the beginning to the completion of the aircraft (spantime), and dummy variables for the labor, management, and industrial relations variables in our model. We also present an ANOVA estimate of the significance of the industrial relations events on overall productivity. The coefficients and standard errors on these dummy variables provide us with estimates of the effect of each industrial relations factor for the relevant time period. Because the plant changed many aspects of its operation during the period, lost experienced managers and workers, the analysis cannot isolate *ceteris paribus* the effect of each industrial relations variable on labor productivity.

---

[6]In addition to the estimates presented in the tables, we also estimated the production function as actual production as a function of planned and the other independent variables in our model. The qualitative results are virtually the same results as are the significance tests. These results are available from the authors.

Our second method of analysis of labor and management practices is more structurally-oriented: we specify a particular counterfactual situation in the plant showing how productivity might have been had it not had the industrial relations innovations that ranged from strikes and work to rule to the implementation of the total quality management program. Here, we use evidence from the plant that is not readily compatible with a regression framework. We examine what would have occurred had a change not been implemented, but use some of the estimated regression parameters to contrast estimated productivity with actual outputs. In this case we use the estimated outputs from the company's forecast, and contrast it with what actually occurred as the organization experienced changes in labor relations. In the case of the total quality program we then follow the firm to its final industrial relations policy, which was the implementation of a rigid monitoring scheme with lots of discipline and less voice by employees in day to day operations.

In Table 1 we show the means and standard deviations of the production-related factors and industrial relations variables used in our multi-variate models of productivity[7]. The data in the Table shows that the complementary plane, which was substantially larger, took about 80 percent more estimated standardized hours to assemble than the plane we employ as the dependent variable in our analysis. The learning curve variable is calculated by the logarithm of the total number of hours of production from the beginning of the period and the logarithm of that value squared. These controls reflect both the literature on productivity, and the models that the production economists in the plant used to model productivity. All other variables are

[7]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.

dummies reflecting the time period that each industrial relations variable was in effect during the period of our before and after design. The O.L.S. regressions correct for first order autocorrelation of the errors.

In Table 2 we present our regression estimates examining the impact of industrial relations factors on productivity[8]. In column one we use only union-oriented factors and production-related variables along with a time counter variable. The dependent variable in the table is the deviation of actual production from planned production. The results in column three show that at approximately 65 planes, learning in production begins to reduce the number of hours per plane, and that there appears to be significant productivity gains over the production cycle as the number of planes assembled increases and a robust learning curve is evident. This result is in contrast to the study of the Lockeed L-1011 aircraft by Benhard (1999). These contrasting results could be due to the fact that the production numbers for the plane we examined was approximately 1,100, which is more than five times as large as the L-1011 production run, or it could be our ability to more fully account for the factors that influenced labor's role and institutional factors in the production of planes.

The results in columns one through four of Table 2 are generally consistent with accepted hypotheses and facts about the role of strikes and work stoppages reducing productivity and firm performance (Becker and Olson, 1987). The third strike was the longest and most bitter one, and it had the largest coefficient value on reducing productivity in column three. Even during strikes some planes were being assembled and delivered, especially during the third strike when

---

[8]In our regression estimates we control for the model change over which occurred in 1980. Although the plane produced looked the same, it was somewhat bigger and could hold more passengers. We also estimated this model for the post 1980 period and found results consistent with those presented in Tables 2 and 3.

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, the work action lasted more than 10 months, and it 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.[9] The union leaders during the early part of the time period, especially number one, were negatively related to productivity, but leader six was associated with increasing labor output in spite of his more aggressive stance toward labor relations with management. His leadership followed the TQM movement and he followed a militant tone in negotiations with management in response to the "softer" style of negotiations followed by his predecessor. Unlike previous studies that have focused mainly on managerial effects on performance, our results suggest that union leadership also matters, and that not including the changing attitudes of the union membership as largely reflected in their choice of a president may bias upward the role of executives on firm performance when unions are present (Leonard, 1990; Murphy, forthcoming).

Column two of Table 2 shows the impact of managerial leaders and their policies on productivity, with controls for production-related variables and the time counter. The major industrial relations innovation during the period of our study was the TQM program with teams and efforts at high levels of employee involvement. Our estimates of the effectiveness of the TQM program as implemented by BP suggest that it did not significantly influence productivity. In contrast, managerial policies that were relatively lax on employee discipline, namely managers one through three in comparison to manager four, reduced labor productivity. The reference

---

[9]These estimates were derived by using the regression coefficient from the model times the average hourly dollar cost of a production worker times the number of weeks that the work to rule policy was in effect by the union.

group manager, number four, used the toughest discipline within the firm. He virtually stopped the use and practice of the employee involvement program because he saw no significant initial productivity gains, and he thought those policies hindered filling customer orders in a timely manner. Union leaders during the period said that he used a "boot camp" type of managerial style.

Since both management and labor related factors may influence the efficiency of productivity within an enterprise, we next develop an additional reduced form model that includes both sets of variables. In column three we present a more fully specified model that includes both union-related and managerial leadership on labor productivity[10]. Our results for the major labor events, strikes and slowdowns, are consistent with the results in columns one and two. Labor relations factors such as strikes and slowdowns are significant and of relatively large magnitude. For example, the work to rule slowdown reduced productivity by 24 percent 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 4 we show our estimates with the planned rate for the larger plane omitted from the regression equation.

The estimates also show the diminished significance of union and managerial leadership, when controlling for industrial relations events in the production function. Although this result may be the consequence of overlaps in timing between the labor and management leaders, our estimates for management regimes are significant for president one relative to

---

[10]In estimating our time series models we varied the timing of the events by one and two months to test for any potential leads or anticipated adjustments as well as lags by the firm to either 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.

president four. However, the timing of two of the labor leaders remains statistically significant and large. Union president one was associated with lower productivity and six was associated with higher productivity relative to the base line president four. The first union president oversaw the first strike and served in a period of traditional labor management relations in the firm and industry, whereas union leader six was a militant leader who took a tough stand in negotiations and sought adversarial day- to- day relationships. Consistent with our other results, the major managerial initiative during the period was the introduction of a TQM program, but this variable was imprecisely estimated in our model. The production-related controls are generally consistent and statistically significant across all specifications with the learning curve being robust, which is consistent with other studies of productivity in manufacturing.

Since there is an overlap between the managers and labor leaders, we next examine the joint effects of union/management leaders and their impact on labor productivity consistent with equations four and five in Table 3. Just as some labor management interpersonal relationships may sour, the attitudes of employees can also turn hostile that later are transformed into poor performance. 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 their position at the bargaining table and in the plant (Lazear, 1995). Therefore, we implement our model by developing mutually exclusive union-management pairs over time with the controls used in our previous estimates in Table 3. The omitted or reference group in our analysis is the toughest managerial leader (leader four) with the second toughest labor leader (president 6). In column 2 of the Table we again drop the estimates of planned hours of production for the second plane produced in the plant to examine if our initial results were biased downward. Our results show that the union-management 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 this occurred toward the end of our period of analysis. These results are consistent with theory that suggests that higher productivity is likely to occur when "hawks" negotiate among themselves (Lazear, 1995). An alternative explaination is that the previous attempts at compromise and cohabitation had quite obviously blown up. This left the company in a more perilous state, with little time for policy changes that might take years to bear fruit. At any rate, the interaction of labor and management pairs as shown in these results is an important factor in productivity, and is consistent with the opening quotation from Freeman and Medoff.

In order to further test for the impact of industrial relations variables on explaining variations in productivity levels, we use an ANOVA analysis. Unlike regression methods, this analysis shows how much of the total variation in productivity can be explained by the specific variable. In Table 4 we show how much of the total variation in productivity is explained by strikes, work to rule, and union and company presidents. In all cases these industrial relations variables are statistically significant and explain a large part of the total variation in productivity over time. Unlike earlier studies of aircraft manufacturing that only use the learning curve as an explanatory variable, not including the role of industrial relations events and actors may result in significant omitted variable bias in understanding manufacturing productivity.

F. From Traditional Labor-Management Practices to EI and Back Again

Since issues of TQM and employee involvement are such important factors in the managerial literature and have taken on an important role in the policy debate within the Dunlop Commission as a recommended way of enhancing American competitiveness, we develop a more structurally-focused model to examine their impact (Commission on Labor Management

Relations, 1995). In our model we use an ARIMA time-series model of production with all planned production in the plant as the independent variable. We use this model to predict what productivity would have been in the absence of the introduction of a TQM program for the 1989 and 1990-period (the time when the firm introduced these policies) relative to what actually happened in the organization. We next simulate the effect of the plant moving from a TQM program in December 1990 to a rigid form of management with strict monitoring of the workforce and little to no employee involvement in plant level labor relations. Figure 3 gives our results for our counterfactual simulation. For the move to employee involvement 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 program was in effect. However, the overall impact 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, it likely was not due to lack of effort or emphasis placed on the TQM policies. Our discussions with management and labor leaders found that much of the failure of employee involvement was a result of top-down management as well as the attempts by first line supervisors to sabotage the TQM program for fear of losing control of production and perhaps losing their jobs under this new program as employees made more decisions about production and team discipline.

Another unique feature of the plant we studied was the plant's switch from strong employee involvement practices to an authoritarian policy. The results in Figure 3 show that productivity increased and labor costs were reduced as a result of this more rigid form of management monitoring and control for a one year period. Unfortunately, we do not have

estimates of the effects of what might have happened to productivity had the plant managers established a more moderate form, i.e., keeping some elements of employee involvement but increasing the level of direct monitoring and discipline. We are able to establish some symmetry of the impact of moving to "high performance workplaces practices" 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 results in the second year of the program. Nevertheless, our results provide some evidence for why firms may choose not to adopt "high performance workplaces" in large older establishments when they do not show immediate positive effects on labor productivity and are costly for the firm to implement.

G. Are there long-term impacts of these industrial relations events?

In Table 5 we simulate, using our regression model, how long following strikes, slowdowns, and employee involvement programs 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 of the return to pre event standardized person hours per plane. In columns one and two of panel a we estimate how long it took for plant level productivity to return to the trend line predicted by the regression model in Table 4, excluding the event that is being forecasted. This table shows how many months it took for the plant to return to within one and five percent 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 three months for the plant to return to within 1 and 5 percent of its pre-strike productivity. For the other events that took place at the plant it took about the same time for organizational labor productivity to return to within 1

and 5 percent of their pre-event levels of average output. This value ranged from one to four months which is not considered long by any standard metric.

The most divisive strike, number three, was also the longest and most bitter, and it was not surprising to find that it took between three and four months for the plant to return to pre-strike levels of productivity. The work-to rule event lasted more than10 months and 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 was able to achieve pre-TQM levels of output within one month after the program ended. Overall, it appears that for this plant the impacts of strikes, work to rule slowdowns, and employee involvement programs have short-lived effects. Although industrial relations events are dramatic and inspire lots of emotional outpourings from both labor and management during and shortly after the event, 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 no long term impact on productivity, they are certain to have strong effects on short term profits. The union in this case did impose significant 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 were able to return to previous levels of production after a relatively short period.

In panel b we compare the costs of the four concerted activities during the period of our study by comparing the dollar costs relative to planned output multiplied by the expected number

planes that would have been delivered, using the three month average prior to the event. The estimates show that even though strikes may have had a more immediate effect on reducing productivity when they occurred, the work-to-rule policy by the union had the largest economic effect on lost productivity. In comparing work to rule to the third strike, it was more than a $6 million loss. The work to rule policy by the union imposed the greatest costs on management with little direct economic loss to the UAW membership.

III. Conclusions

We have shown the impact of major industrial relations changes on productivity. We examined a major firm in an oligopolistic industry that is the largest manufacturing exporter, and second largest manufacturing employer in the United States. We use a before and after research design, over an 18-year period with monthly data, combined with in depth interviews with the leading actors in industrial relations. This analysis provides a unique opportunity to examine the impact of industrial relations by minimizing unobserved heterogeneity in production through examining one plant that produces a standardized product. Our results show that labor and industrial relations factors do matter a great deal on labor productivity in terms of statistical significance, relative magnitude, and costs. Strikes, slowdowns, and union leaders influenced the productivity of this plant by large percentages and absolute dollar amounts. Our findings are unique in showing that omitting factors such as union leadership and related labor relations events may result in a misspecified equation when analyzing firm performance. The major managerial innovation, TQM, did little to increase productivity over the short time that it was in place, and it resulted in a slight reduction in labor productivity and increased labor costs. However, the practice was showing a positive effect when it was abandoned during its second year. How and why TQM is adopted may be just as important as whether it is adopted.

Another unique part of our study was the ability to show the movement from traditional management to employee involvement and back again. The movement to an authoritarian mode of management from TQM showed positive productivity effects in the short run. We hope to gather more data from this plant to examine the longer run effects of greater discipline and closer monitoring of the production workforce 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, when labor organizations are present, may overstate the role of executives. 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, but do not succeed, in implementing "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. Our example of one plant does not fully address all the issues of the role of union and management policies and practices, and may in part reflect the unique characteristics and corporate culture of this establishment. We nevertheless encourage this type of detailed examination of plants in sufficient depth so that the role of industrial relations policies and practices on organizational efficiency can be rigorously examined in a more thorough fashion.

Bibliography

Arrow, Kenneth J. "The Economic Implications of Learning by Doing." *Review of Economic Studies* 29 (3) June 1962, pp.155-73.

Asher, Harold. *Cost-Quality Relationships in the Airframe Industry*, Santa Monica, Ca. The Rand Corporation, 1956.

Becker, Brian and Craig Olson, "Labor Relations and Firm Performance," in M. Kleiner et. al., *Human Resources and the Performance of the Firm*, Madison, Industrial Relations Research Association, 1987.

Benkard, C. Lanier, "Learning and Forgetting: The Dynamics of Aircraft Production," National Bureau of Economic Research Working Paper 7127, Cambridge, Ma., May 1999, pp. 52.

Commission on the Future of Labor-Management Relations, GPO, Government Printing Office, 1995.

Devine, Theresa J. and Nicholas M. Kiefer, *Empirical Labor Economics: The Search Approach*, Oxford University Press, New York, 1991.

Freeman, Richard B., and James Medoff, *What Do Unions Do?*, Basic Books, New York, 1984.

Freeman, Richard B., and Morris M. Kleiner, "The Last American Shoe Manufacturers: Changing the Method of Pay to Survive Foreign Competition," National Bureau of Economic Research Working Paper 6750, Cambridge, Ma. October 1998, p. 46.

Freeman, Richard B. and Joel Rogers, *What Workers Want*, Cornell University Press, 1999.

Ichniowski, Casey, Kathryn Shaw, and Giovanna Prennushi, "The Effect of Human Resource Practices on Productivity: A Study of Steel Finishing Lines," *American Economic Review*, Vol. 87, No. 3, June 1997, pp.291-313.

Karier, Thomas, "Unions and Monopoly Profits," *Review of Economics and Statistics*, 67, 1985, pp. 34-42.

Kleiner, Morris, Gerald Nichelsburg, and Adam Pilarski, "Monitoring, Grievances, and Plant Performance," *Industrial Relations*, Vol.34, No.2, April 1995, pp. 169-189.

Kuhn, James, *Bargaining in the Grievance Settlement,* New York, Columbia University Press, 1961.

Lazear, Edward, *Personnel Economics*, MIT Press, Cambridge, MA. , 1995.

Leonard, Jonathan, "Executive Pay and Corporate Performance," *Industrial and Labor Relations Review,* Vol. 43, No. 3, S1990, pp. 13- 29.

Little, Roderick, and Daniel Rubin, *Statistical Analysis with Missing Data*. New York, NY: John Wiley and Sons, 1987.

Murphy, Kevin J., "Executive Compensation," *Handbook of Labor Economics*, Orley Ashenfelter and David Card, ed., North Holland, forthcoming.

Napier, D., "1995 Year End Review and Forecast, "Aerospace Industry Association of America, 1996.

National Research Council, The Competitive Status of the U.S. Civil Aviation Manufacturing Industry, 1985.

Navarro, Peter, "Union Bargaining Power in the Coal Industry, 1945-81." *Industrial and Labor Relations Review,* Vol. 36, No. 2, January 1983, pp. 214- 229.

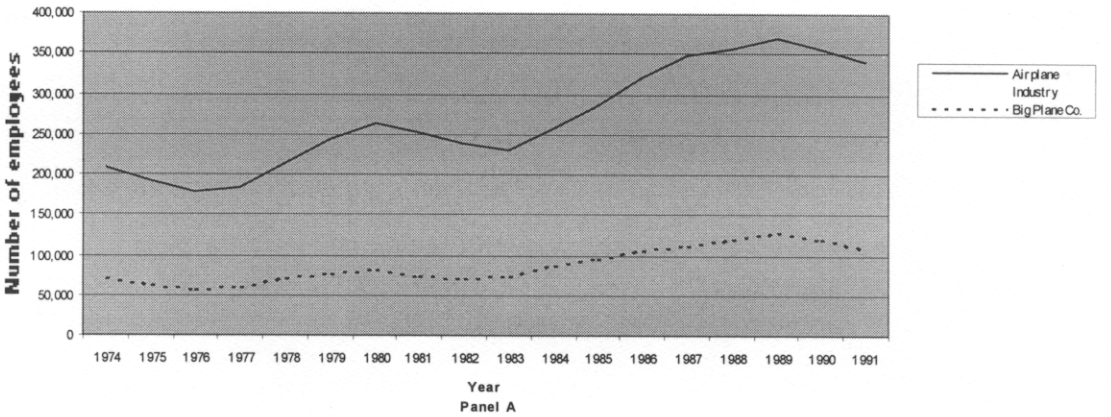
Ruff, Daniel, "What Happened at Highland Park?", National Bureau of Economic Research unpublished manuscript, 1996.

Thompson, Peter, "How Much Did the Liberty Shipbuilders Learn? New Evidence for an Old Case Study," Working Paper, University of Houston, 1999, pp. 41.

Walton, Richard E. and Robert B. McKersie, *A Behavioral Theory of Labor Negotiations*, ILR Press, Ithaca, New York, 1991.

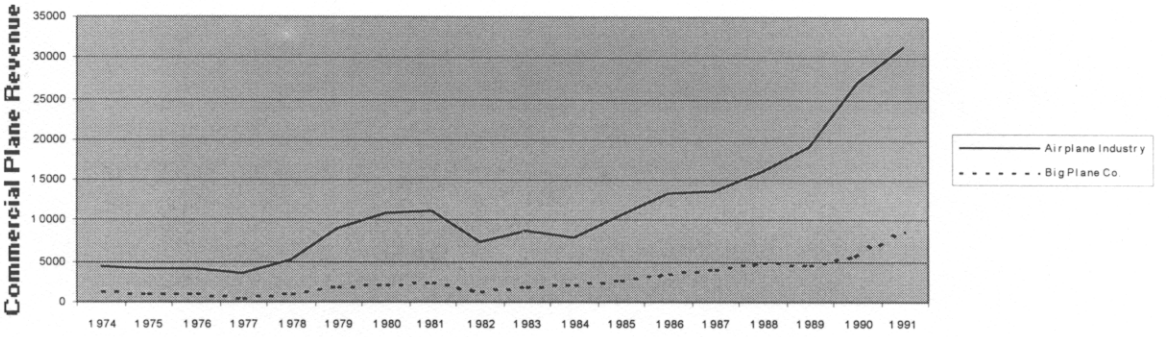
Figure 1

Comparison of Employment in Big Plane Co. and the Commercial Airplane Industry



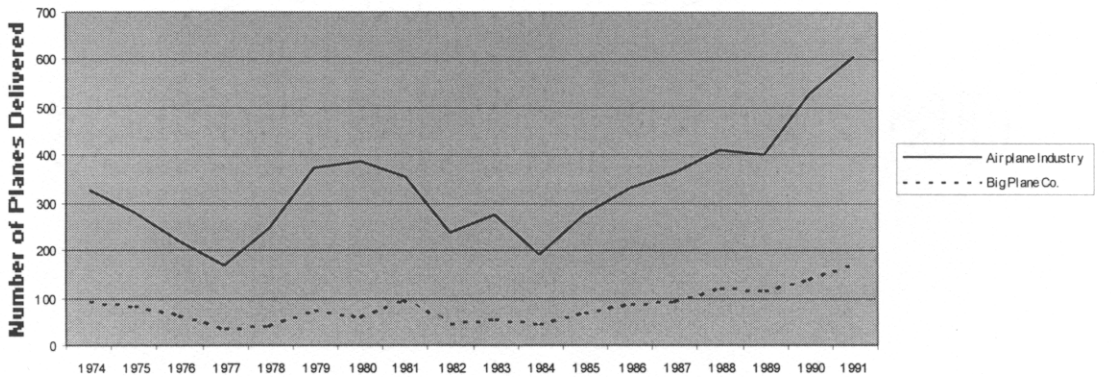
Panel A

Comparison of Commercial Plane Revenue in Big Plane Co. and the Commercial Airplane Industry



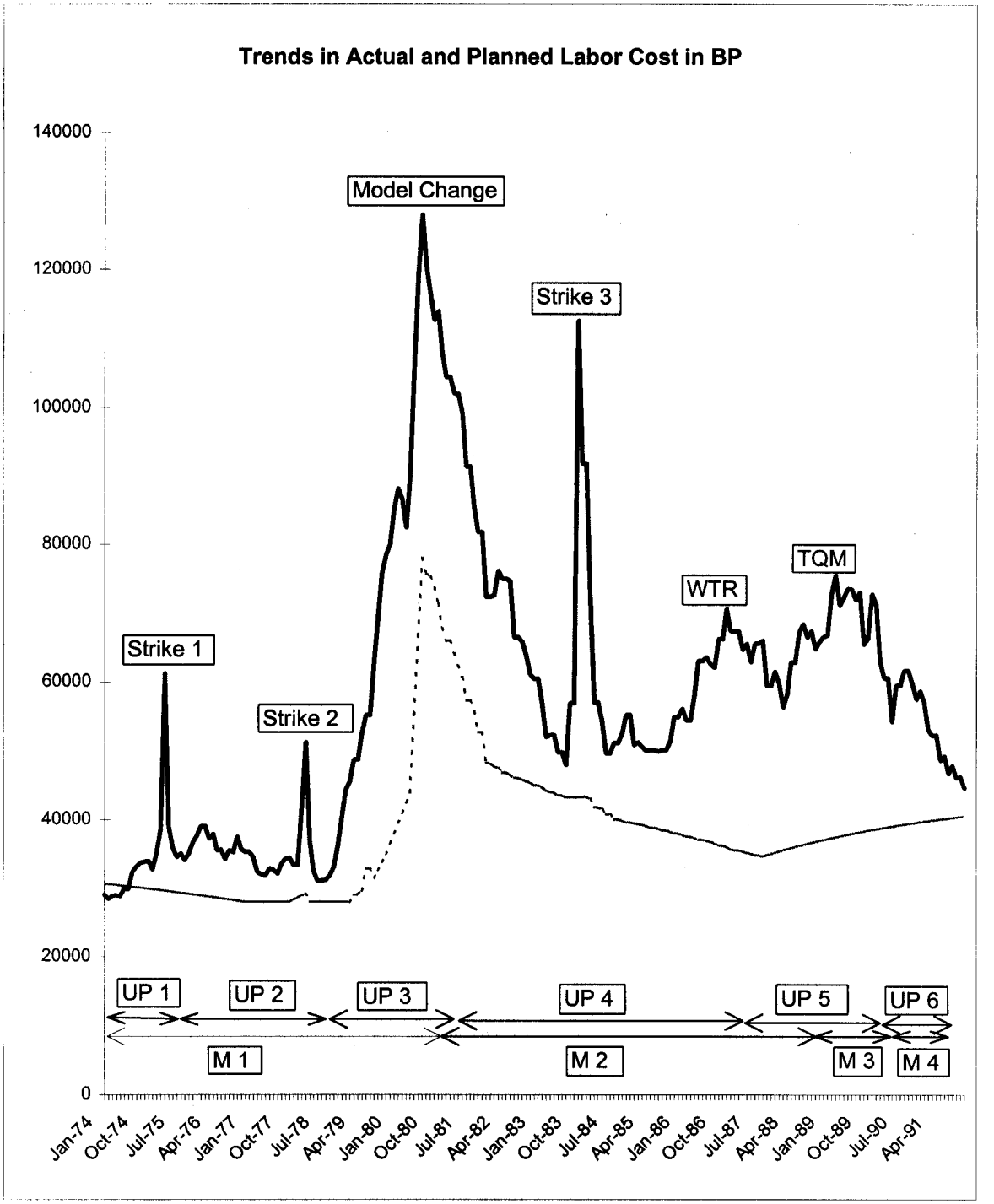
Panel B

Comparison of Commerical Planes Delivered by Big Plane Co. and Commercial Airplane Industry



Panel C

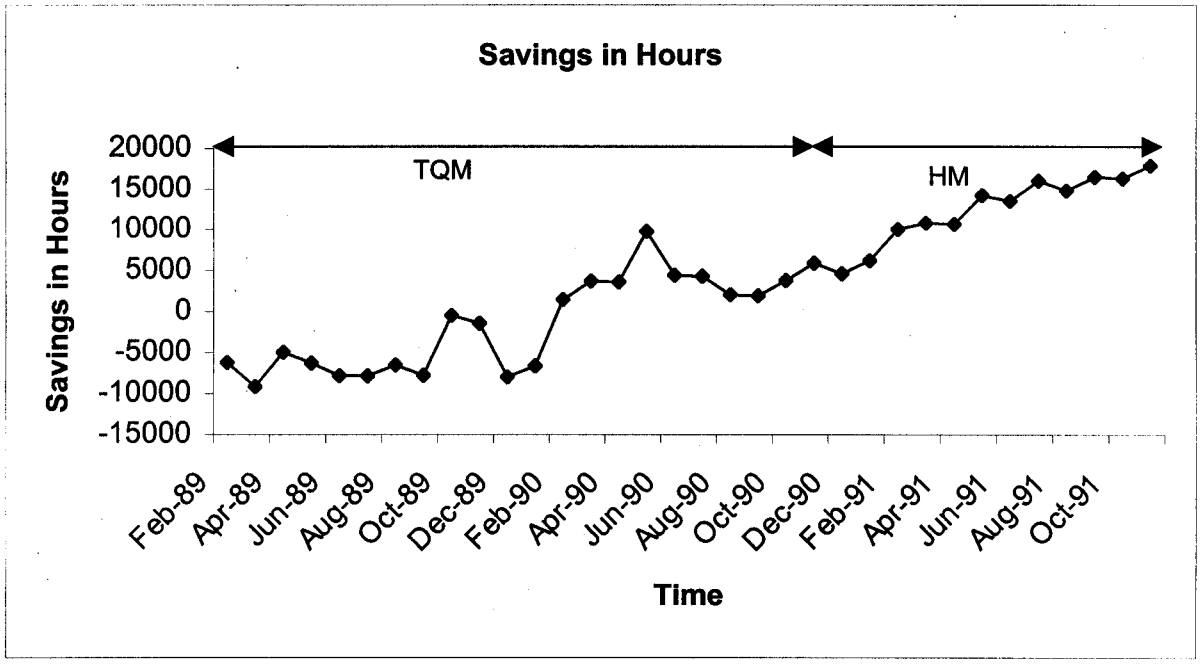
Figure 2

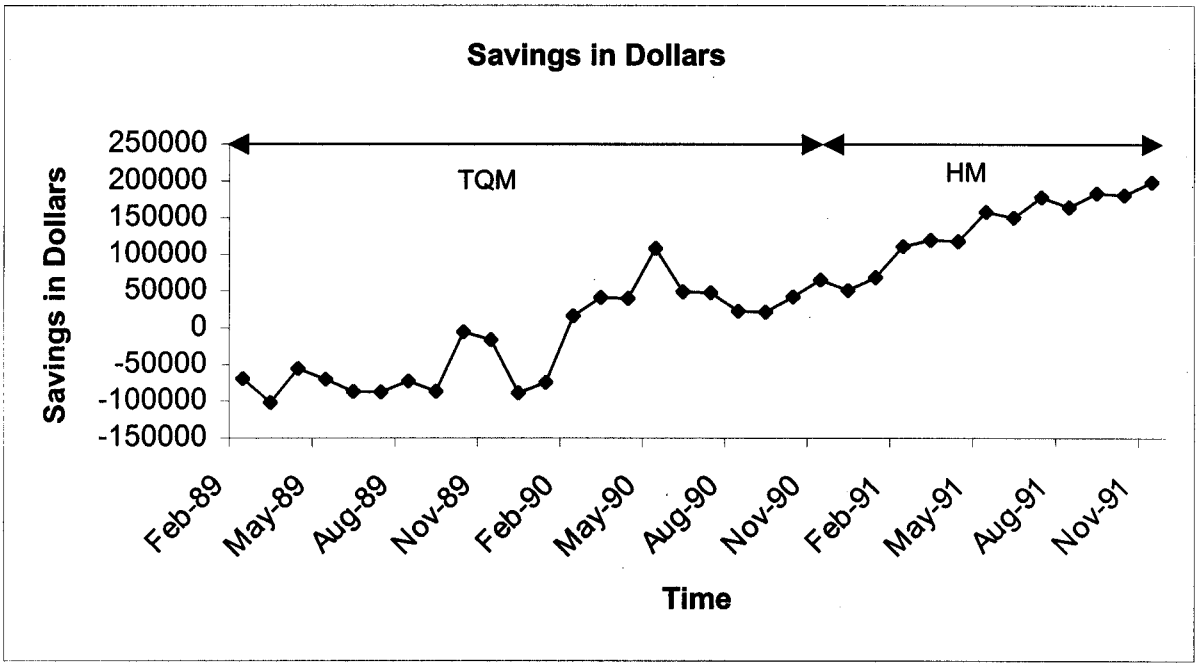


Note:

1. Dotted line is planned labor cost. Solid line is actual labor cost.
2. Strike 1: Feb-May, 1975. Strike 2: Dec. 1977-Mar. 1978. Strike 3:Sept. 83-Feb. 1984.
3. Model Change: Jan. 1980-Dec. 1982.
4. 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.
5. Manager 1: Jan. 1974-Feb. 1981. Manager 2: Mar. 1981-Dec. 1988. Manager 3: Jan. 1989-Aug. 1990. Manager 4: Sept. 1990-Nov. 1991.
6. TQM: Feb. 1989-Nov. 1990. Work to rule: Dec. 1986-Sept, 1987.

Figure 3. Estimated 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. 33,838 increase in standard hours and a $367,283 increase in labor costs.
3. Total estimated effect of moving from TQM to heavy monitoring (HM) 151,322 reduction in standard hours and a $1,682,698 reduction in labor costs.

Table 1

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

	Mean	Standard Deviation
	58,051.97	20,964.08
Average Standardized Hours Per Plane		
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
Total Quality Management Program	0.10	0.30
Model Change	0.17	0.37
Planes Delivered per Month	5.63	4.06

Table 2
Impact of the Overall Industrial Relations (IR) Environment on Log of Difference Between Actual and Planned Hours per Plane in the BP Plant*

	Union-related factor (1)	Managerial factors (2)	Overall IR factors (3)	Overall IR factors without other Outputs (4)
Constant	27.63(34.68)	124.74*(31.79)	38.17(35.27)	-76.11*(21.91)
Strike 1	.41*(.16)		.36*(.17)	.47*(.17)
Strike 2	.38*(.18)		.39*(.18)	.37*(.17)
Strike3	.38*(.17)		.45*(.17)	.37*(.15)
Work to Rule	.27*(.10)		.24*(.10)	.24*(.10)
Union President 1	1.09*(.28)		1.12*(.30)	.91*(.30)
Union President 2	.05(.19)		.11(.21)	-.13(.21)
Union President 3	-.11(.14)		-.08(.17)	-.06(.19)
Union President 5	-.11(.13)		-.12(.13)	-.20(.12)
Union President 6	-.62*(.17)		-.45*(.19)	-.49*(.18)
Total Quality Management Program		.17(.15)	.15(.13)	.02(.13)
Manager 1		.92*(.24)	.35(.25)	.19(.25)
Manager 2		.83*(.17)	.39*(.17)	.19(.17)
Manager 3		.46*(.17)	.16(.16)	.13(.17)
Spantime	-.00(.00)	-.00(.00)	-.00(.01)	-.00(.01)
Log(Parts Shortage)	.07*(.02)	-.01(.02)	.06*(.02)	.08*(.02)
Time Trend	.01(.01)	.01*(.01)	-.01*(.01)	.00(.00)
Log Learning Curve	20.26*(4.17)	15.25*(4.57)	23.74*(4.60)	10.55*(3.22)
Log Learning Curve Squared	-.73*(.16)	-.59*(.18)	-.87*(.18)	-.36*(.12)
Lag of the Dependent Variable	.65*(.06)	.70*(.06)	.64*(.05)	.71*(.05)
Planes Delivered per Month	.01(.01)	.00(.01)	.01(.01)	.01(.01)
Log(Planned Hours Per Second Plane)	-14.08*(3.96)	-18.83*(4.02)	-16.85*(4.11)	----------
Model Change	-.01(.09)	-.01(.09)	.03(.09)	.16(.09)
R^2	.92	.88	.93	.92

Standard errors are in parenthesis with corrections for first order autocorrelation, and an asterisk indicates significance at the 95% confidence level

Table 3

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

	Overall IR factors (1)	Overall IR factors without other Outputs (2)
Constant	37.72(35.29)	-76.61*(21.97)
Strike 1	.35*(.17)	.47*(.17)
Strike 2	.39*(.18)	.37*(.17)
Strike 3	.45*(.17)	.37*(.15)
Work to Rule	.24*(.10)	.24*(.10)
Manager 1- Union President 1	1.93*(.34)	1.60*(.35)
Manager 1- Union President 2	.92*(.28)	.60*(.28)
Manager 1- Union President 3	.72*(.25)	.62*(.26)
Manager 2- Union President 3	.76*(.27)	.62*(.28)
Manager 2- Union President 4	.84*(.20)	.68*(.20)
Manager 2- Union President 5	.72*(.16)	.48*(.16)
Manager 3- Union President 5	.49*(.16)	.42*(.17)
Manager 3- Union President6	.16(.16)	.13(.17)
Total Quality Management Program	.15(.13)	.02(.13)
Spantime	-.00(.00)	-.00(.00)
Log(Parts Shortage)	.06*(.02)	.08*(.02)
Time Trend	.01*(.01)	.00(.01)
Log Learning Curve	23.74*(4.61)	10.55*(3.22)
Log Learning Curve Squared	-.87*(.18)	-.35*(.12)
Lag of the Dependent Variable	.64*(.05)	.71*(.06)
Log(Planned Hours Per Second Plane)	-16.85*(4.11)	
Model Change	.03(.09)	.16(.09)
Planes Delivered per Month	.01(.01)	.01(.01)
R^2	.93	.92

* Standard errors are in parenthesis with corrections for first order autocorrelation, and asterisks indicate significance at the 95% confidence level

Table 4
Analysis of Variance of the Industrial Relations Events on Log of Difference Between Actual and Planned Hours

Source	Partial Sum of Squares	Degree of Freedom	Mean Sum of Squares	F
Strike	4.46	3	1.49	2.51*
Residual	120.85	204	.59	
Total	125.32	207	.61	

Source	Partial Sum of Squares	Degree of Freedom	Mean Sum of Squares	F
Union President	59.17	5	11.83	36.14*
Residual	66.15	204	.33	
Total	125.32	207	.61	

Source	Partial Sum of Squares	Degree of Freedom	Mean Sum of Squares	F
Manager	26.32	3	8.77	18.08*
Residual	99.00	204	.49	
Total	125.32	207	.61	

Source	Partial Sum of Squares	Degree of Freedom	Mean Sum of Squares	F
Model	67.11	11	6.10	20.55*
Strike	6.16	3	2.05	6.92*
Union President	39.01	5	7.90	26.27*
Manager	1.78	3	.59	2.00
Residual	58.20	196	.30	
Total	125.32	207	.61	

* significant at the 95% confidence level.

Table 5. Impact of Industrial Relations Events

Panel A. Number of Months for Productivity Levels to Return to Pre-Industrial Relations Event Values.

Industrial Relation Events	Months to Return to within 1% of pre-event productivity	Months to Return to within 5% of pre-event productivity
Strike1	1	1
Strike 2	3	3
Strike3	4	3
Work to Rule	1	1
TQM	1	1

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

b. 1% and 5% refer to within 1% and 5% of the prior productivity levels.

Panel B. Cost of Concerted Event Relative to Planned Productivity

Industrial Relation Events	Dollar Costs
Strike 1	$2,674,325
Strike 2	$1,257,177
Strike 3	$14,139,366
Work to Rule	$20,887,238

Note: cost = (actual labor cost-planned labor cost per plane)* (average number of pre-event planes delivered per month) *average hourly wage.