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October 1994

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Keywords

employee, skill, pay, program, productivity, quality, labor, cost, injury, workforce, compensation. work, pay system

Comments

Suggested Citation

Murray, B. & Gerhart, B. (1994). *A field study of early organizational outcomes from the introduction of a skill based pay program* (CAHRS Working Paper #94-26). Ithaca, NY: Cornell University, School of Industrial and Labor Relations, Center for Advanced Human Resource Studies.
<http://digitalcommons.ilr.cornell.edu/cahrswp/251>

WORKING PAPER SERIES

A Field Study of Early Organizational Outcomes from the Introduction of a Skill Based Pay Program

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Working Paper 94 – 26



A Field Study of Early Organizational Outcomes from the Introduction of a Skill Based Pay Program

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Working Paper 94-26

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Author notes: Completion of this study was supported by the Center for Advanced Human Resource Studies, Cornell University
We gratefully acknowledge the assistance and suggestions of Marty Wells and Larry Williams

This paper has not undergone formal review or approval of the faculty of the ILR School. It is intended to make results of Center research, conferences, and projects available to others interested in human resource management in preliminary form to encourage discussion and suggestions.

Abstract

Despite the documented increased use of skill or knowledge based pay programs in organizations, little evidence exists to demonstrate whether these plans achieve the results that are intended. This study, a quasi-experimental, empirical test of the organizational outcomes from the introduction of a skill based pay program, addresses this need. Using time series data from nonequivalent groups, productivity, quality, labor cost and injury outcomes are examined over a 37 month period. The results support greater potential workforce flexibility, greater productivity (48\$), and lower labor cost per part (16\$). Compared to a control group, experimental group data also demonstrate more favorable quality outcomes. Injury frequency outcomes are not supported by the data, and in fact suggest that injuries may increase with the introduction of skill based pay. These results support both the behavioral and operations theories underlying skill based pay and add significantly to the knowledge regarding compensation interventions in general.

To enhance competitiveness, organizations increasingly are taking a second look at the way they design pay systems. Some are turning away from the traditional job-based pay structure to skill-based pay. Lawler, Mohrman, and Ledford (1992) report that about 51% of large companies are using skill or knowledge based pay programs in at least a small portion of their organization. While the traditional job-based pay program considers only the attributes of the task to be completed, these skill-based pay programs emphasize and reward the work related attributes of employees. By paying for the attributes (knowledge, skills, abilities) of the individual, organizations hope to direct the attention of the employee to developmental opportunities and to encourage skill-seeking behavior. Practitioner journals report that, by redirecting the attention of the worker and increasing the workforce skill base, these organizations expect to gain increased workforce flexibility, decreased labor cost, increased product quality, and increased productivity (e.g., Burning, 1989; Franklin, 1988; Lawler & Ledford, 1987; Tosi & Tosi, 1986; Gupta, Jerkins & Curington, 1986; Jerkins & Gupta, 1985).

Most empirical evidence regarding the effects of skill-based pay is limited to exploratory surveys administered to human resource managers or personnel directors at facilities that use these pay plans (Gupta, Jerkins & Curington, 1986; Gupta, Jerkins, Curington, Clements, Doty, Schweizer & Teutech, 1986; Jenkins, Ledford, Gupta & Doty, 1992). They suggest that there may be some support for the assertions of increased workforce flexibility, decreased labor cost, increased product quality, and increased productivity.

While these exploratory studies are important preliminary steps, each survey is constrained by important limitations. First, the managers responding to each survey may be the same managers who designed or implemented the pay program; consequently, their answers may reflect a personal bias in favor of the plan, rather than any true effect. Second, many of the survey questions require the respondent to make judgments about product quality or productivity levels or comparisons to other facilities. The human resource managers may or may not have the data to make these assessments accurately. Furthermore, the wording of the questions and the response sets on the survey are at times ambiguous. For example, no standard definition of productivity is given, or responses are limited to vague level indications such as "Better" or "A Lot". Finally, the surveys were administered only to facilities that currently have the plans. Especially for comparative survey questions, it would be useful to have responses from facilities that have chosen not to implement skill based pay systems or have discontinued a skill based pay system.

Addressing some of these limitations, Vaughan et al. (1991) examine the job design, pay, and outcomes for multiskilled health professionals. Important aspects of their study are that

they examine both job enlargement and enrichment and include respondents that did or did not provide some form of skill related pay. Their results include some important and interesting findings not elsewhere available. First, over half (53%) of the respondents to their survey report providing no additional compensation for multiskilled health professionals. Second, of the respondents to the survey who were involuntarily placed into a multiskilled work environment, those who were being paid a differential for the multiskilled work and involved in job enlargement report more favorable attitudes toward multiskilled work. Third, hospital administrators in facilities not paying a skill based differential report that their employees find the job more interesting and that they experience greater difficulty with scheduling and coordination and with the maintenance of skill competency in both a job enlargement and job enrichment/enlargement environments. Fourth, when skill based pay differentials are present, hospital administrators report a greater positive impact on the quality of patient care due to enlarged/enriched jobs and a greater intent to increase the use of multiskilled health professionals than those facilities not paying the differential. The results of this study for skill-based pay and job design are certainly encouraging; however, two important limitations to this study must be noted. First, the study surveys perceptions only; no objective outcome data were gathered. Second, the respondents to the survey are the hospital executives; conclusions regarding employees' behavior and attitudes is based solely on the perception and evaluation of the executive.

The present study addresses the limitations of the prior studies and adds significantly to the evidence regarding outcomes of skill based pay. Specifically, this study seeks to answer the question of which organizational outcomes (e.g., productivity, quality, injury rates) are affected by the implementation of skill based pay and to what extent. The study design addresses the limitations of the survey method by using time-series data and a nonequivalent control group. The usefulness of the results is further enhanced by using "hard" measures of outcomes (e.g., physical output counts).

This study also adds to the compensation-based intervention literature in general. Petty, Singleton, and Connell (1992) used a quasi-experimental design to examine control and experimental groups for changes in performance due to an incentive plan. Recent articles (Wagner, Rubin, and Callahan, 1989; Hatcher and Roes, 1991) also have employed research designs based on interrupted time series. This study adopts their approach to analyzing compensation interventions and in some cases is able to enhance the analysis by including a nonequivalent control group. Furthermore, this study also uses objective measures of productivity and quality to obtain estimates of effect sizes.

Theory & Model

A model of the link between a skill-based pay program and its organizational outcomes is developed from multiple theoretical perspectives. Because the process is complex, one must consider what behavior the pay system directly influences, what other organization systems the pay system supports, and how the behavior and systems come together to affect the organizational outcomes. Figure 1 is one representation of this model between the skill-based pay system and organizational outcomes examined in this study. While its simplicity may be deceiving, it illustrates the main factors and the integration of theoretical approaches.

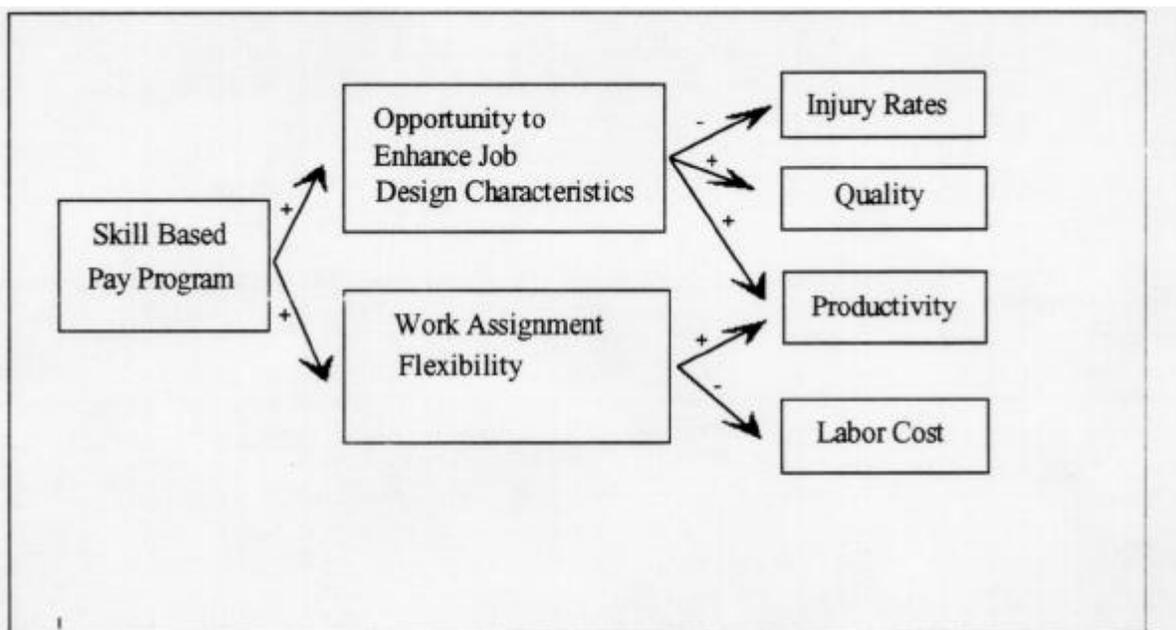


Figure 1. Model of the Effect of Skill Based Pay on Organizational Outcomes

Consider the following perspectives in light of this model: a behavioral approach and an operations approach. The behavioral approach considers the interaction of the worker and the work. A skill based pay system allows the organization the opportunity to change the nature of the work (e.g., grouping or variety of tasks), and therefore, possibly affect the attitude or behavior of the worker. The operations approach considers the scheduling of production jobs and the constraints of labor assignment flexibility. Because a goal of the skill based pay system is to affect the flexibility of the workforce, the program decreases labor constraints on job scheduling and allows more efficient production scheduling.

Workforce Flexibility

Perhaps the most direct link between skill-based pay incentives and organizational outcomes is increased workforce flexibility. Optimization of human resource usage is constrained by the skill limitations of individual workers. The greater the number of constraints on labor scheduling, the more limited is the domain of possible schedules. Depending upon the needs of the production and the skill sets of the workers, maximization of productivity may be severely limited. For instance, consider just-in-time production. The productivity of a given workforce is dependent upon the available flexibility in job assignment to the work that needs to be done at any given time. The lesser the flexibility within the workforce, the greater the number of skill-specific trained workers needed to complete the production process. Skill-based pay's role is to increase the value and flexibility of the human resources, and in turn increase productivity and decrease staffing levels and labor cost.

Production Scheduling and Optimization. The notion of increasing workforce flexibility to enhance production outcomes is not new to operations management theory. The research on labor flexibility has tended to focus on the optimization of systems of outcomes including productivity, time in system, labor transfers, and job-lateness, and, in addition to machine flexibility, has been examined as a second constraint on work scheduling in job-shop operations (e.g., Allen, 1963; Nelson, 1967; Fryer, 1973, 1974; Park and Bobrowski, 1989). The consistent theme across the research results is that greater labor flexibility can have a significant effect on various production outcomes even when considering machine flexibility constraints and alternative job scheduling rules.

The most prevalent result across studies is that increased labor flexibility yields a decrease in the mean flow-time of the job (Allen, 1963; Nelson, 1967; Fryer, 1973, 1974; Park & Bobrowski, 1989). Essentially, the flexibility allows labor to be assigned by prioritization (e.g., queue length, due date tightness). As flexibility increases, labor utilization increases (Allen, 1963), bottlenecks are alleviated, and jobs are completed faster. Accordingly, this flexibility has also been demonstrated to decrease lateness measures (Park & Bobrowski, 1989). These research findings imply that flexibility allows lower headcount and less overtime labor cost per unit produced.

A unique feature of this research is the assumption of competency. Each of the studies reported makes the explicit assumption that if a worker is eligible to be assigned to a task, the worker is fully competent with the task. The important implication for choice of pay system is predicting whether the worker will seek and can demonstrate competency. In general, unlike the typical job-based pay system, the skill based pay system motivates skill-acquisition and

demands demonstration of competency. Vaughan et al. (1991) provide support for the greater likelihood of maintaining skill competency levels when skill based pay is used. While the results regarding flexibility may hold regardless of pay plan, they seem more appropriate to a skill-based than a job-based environment.

Potential Flexibility. The underlying premise that skill based pay motivates skill acquisition and skill acquisition allows greater potential flexibility in work assignment is evident in many of the outcome propositions. Without increased flexibility, increases in productivity and quality and decreases in injury rates cannot necessarily be supported. The change in flexibility is essential, then, to the working of skill based pay. From a motivation perspective, the reward of pay for skills may be a valued outcome that directs the behavior of the individual toward skill acquisition. The greater number of skills acquired by members of the workforce, the greater the potential flexibility of the workforce.

H1: Over time, workers in a skill based pay environment will seek skill certification and the average skill level of the work force will increase.

Quality

A second expected organizational outcome of a skill-based approach to pay is increased product quality. As individuals learn more of the jobs necessary to complete the production of the product, they begin to understand the importance of each step in the process. Employees may be expected to gain an understanding of quality inspection (Jenkins & Gupta, 1985). In the service industries quality may be increased because each agent is able to fulfill a greater range of the customer's needs (Schuster & Zingheim, 1992). Finally, the job characteristics model (Hackman and Oldham, 1976) provides support for changes in behavior, including attention to quality, through enhanced job design and internal work motivation. These job redesigns can be supported by skill based pay.

Enhancing Job Design. Hackman & Oldham (1980) make the job characteristics model especially relevant to the present study by explicitly recognizing the importance of a supportive compensation system. Consider the nature of a skill-based pay system. Because its purpose is the motivation of skill acquisition, it is especially supportive of job redesign for higher motivating potential jobs. First, individuals who possess a greater number of skill competencies can be assigned to jobs of greater skill variety. Second, jobs can be designed for individuals that allow the more skilled worker to complete an entire unit and increase task identity. Third, if through skill-seeking behavior the individual gains a greater understanding of the importance of the task at hand to the work of others, the job takes on greater task significance. Fourth, if increased skill competencies allow an individual greater control over the work process and less supervision,

then the individual may experience a greater sense of autonomy. Fifth, greater skill acquisition may enable a worker to personally conduct quality inspection or may give the worker access to information regarding productivity; thus, the supportive role for skill-based pay is to increase the feedback potential of the job.

Especially relevant to the present study are the organizational outcomes of motivational job design. These outcomes include internal work motivation, quality of work performance, satisfaction with work, and absenteeism/turnover levels. Fried & Ferris (1987) provide nets-analytic support for the relationships between task characteristics and absence behavior and work performance. Likewise, McEvoy & Cascio (1985) provide evidence for the link between job enrichment and turnover. A question remaining for this study is the impact a supportive pay system might have on the organizational outcomes.

As discussed, a preliminary answer to the quality question is provided by Vaughan et al (1991) by surveying differences in outcome perceptions from job designs with and without skill based pay. When skill based pay differentials are present, hospital administrators report a greater positive impact on quality of patient care by multiskilled health professionals than when skill based pay is not present. Despite the limitations of perceptual measures surveyed from program managers only, there is evidence that pay has an incremental effect over or interacting with job design effects. Second, Hackman & Oldham (1980) suggest both the possibility of enhanced quality from job design and the supportive role played by the reward system. Third, Jenkins & Gupta (1985) suggest that the increased number of jobs learned by an individual influences behavior in regard to quality through the individual's understanding of the production process and quality testing. Assuming the enhanced understanding or attention to quality,

H2: A skill based pay program is associated with greater product quality than is a job based pay program.

Productivity

In addition to quality, organizations expect an increase in long term productivity from skill-based pay systems. Because employees can be assigned where they are most needed and because higher quality loses less items to scrap, more completed items are produced in a specific time period. The results of the Jenkins et al. (1992) survey, the assertion that job design may lead to greater levels of internal motivation, and the benefits of labor scheduling flexibility all seem to support the potential for greater productivity from a multi-skilled workforce.

H3: A skill based pay program is associated with greater productivity than is a job based pay program.

Labor Cost

A potential disadvantage of skill based pay is its effect on labor cost. As employees progress through the pay structure, individual (possibly total) labor cost rises. Unless there are related increases in productivity and quality with decreases in headcount, labor cost could become a hurdle that jeopardizes the viability of the program. As discussed, there are, however, reasons to believe that flexibility, productivity, and quality will be affected by this pay program.

Related to the increase in work assignment flexibility is the expected decrease in labor cost. Among the factors influencing labor cost are staffing levels and time to complete work orders. If a skill-based pay system allows greater flexibility in work assignment, then less skill-specific employees are needed to complete the production process. No longer is the organization required to employ a specific person or staff for every job; rather, the organization can have fewer total workers with more "utility" style workers who can be assigned to tasks only when they need to be completed (Lawler, 1990). As headcount declines, overall labor cost and benefit expense declines. Additionally, less supervision may be required, so there may be less supervisory staff labor cost (Bunning, 1989). The time necessary to complete work orders also might be reduced if workers can be shifted to those activities that most need to be completed; savings might be realized as reduced overtime. Finally, given the increased quality that might result from enhanced work design, the number of defective items would decline, resulting in less labor hours (cost) per part produced.

H4: A skill based pay program is associated with lower labor cost than is a job based pay program.

Injury Rates

Like quality and productivity, the safety of workers might be enhanced through job design; thus, a pay system that supports alternative job designs might be associated with lower worker injury rates. Two approaches seem relevant regarding injury rates. One might argue that employees moving among many tasks are less familiar with the risks of any one task or the peculiarities of any one machine than a specialist who constantly performs the task or operates the machine. Injury frequency also may be a function of employee attitudes (e.g., Jordan and Simons, 1984; Koczal, 1979). Depending on how the program is implemented and received by employees, injury rates may actually increase. However, given the recent awareness of repetitive motion disorders, ergonomic prudence suggests that injuries can be reduced through rotation and limiting time spent on specific repetitive tasks. Additionally, activation theory (Gardner, 1990; Gardner & Cummings, 1988; Scott, 1966) suggests that the simple periodic

movement among different tasks might relieve psychological fatigue and reduce non-task related behavior, heightening awareness of current behavior and safety concerns.

H5: A skill based pay program is associated with lower injury rates than is a job based pay program.

METHOD

The Sample

To test the hypotheses an experimental facility that introduced a skill based pay intervention was identified. Additionally, a nonequivalent control facility that used a single job based plan throughout the experiment period was identified. The control facility was chosen from a number of alternatives because company managers felt that it represented a good match, or comparison, to the experimental facility based on product industry, technology, procedures, and history. The experimental facility was composed of nine experimental groups. Monthly time-series data across 37 periods were collected on each group to perform interrupted time-series analyses.

The Company. Both the control and experimental facilities are owned and operated by a single corporation. The corporation had 1990 sales in excess of \$5 billion. The corporation competes in several product markets, but the largest portion of its business is in the automotive systems industry. Its automotive systems segment maintains facilities that produce either passive or inflatable restraint systems. The company sells these components directly to automobile assembly organizations. Although sales of both restraint systems are dependent upon fluctuations in the automobile sales market, demand for inflatable systems has been in a growth stage, while demand for passive systems has been stable, but extremely competitive. As a cost saving measure, the company has been transferring some production operations to lower cost countries. These moves have reduced domestic production and staffing levels both in the passive and inflatable restraint systems facilities.

The Control Facility. This facility is located in the southern United States in a predominantly rural area. The plant was built in the late 1970's and purchased by the company in the mid 1980's. Over the years the plant has been active in producing both passive and inflatable restraint systems. During the period of the present study, the plant has been producing passive restraint systems only. This particular facility is not unionized, and no unionization movements are anticipated. In recent years, the plant has experienced a reduction in production orders due both to declining demand and movement of production work to other nations. As a result, the facility has experienced a series of involuntary layoffs, with major

layoffs occurring in 13 November, 1991 and January, 1992. Currently, management has no plans for further staff reductions from their current level of 300 employees.

The management at this facility proactively tries to de-emphasize pay as an employment issue. Pay level is described as "at market" for surrounding plants. Pay adjustments are administered at a time of year opposite to pay changes at surrounding plants in order to de-emphasize any comparison of pay level changes. The pay structure is a job-based system. The management has investigated skill-based pay systems, but in accordance with the de-emphasis on pay philosophy have chosen not to make changes in the base pay structure.

Management has chosen to proactively promote the development and empowerment of teams and participation in the facility. The teams are structured around production activities, cost-reduction, and safety. Employee teams have direct input toward the process and flow of work, use of company materials toward cost reduction, and administrative procedures that affect the use of supplies. Participation is encouraged through work-line meetings, regular opportunities to discuss production problems or suggestions with management on the plant floor, regular and ad hoc committee meetings, and an open-door policy. The work of the teams and their input are reinforced by non-financial recognition programs. Interviews with managers and with production employees enthusiastically support the confidence, trust, and usage of these team and participation opportunities.

The Experimental Facility. This facility is located in the southwestern United States near a metropolitan area. The plant was purchased in 1989 from another automotive components producer. The facility manufactures inflatable restraint systems only. It employs approximately 1200 people at two sites. The present study focuses on the component assembly site which administers a skill-based pay system for approximately 500 employees.

Although the market for inflatable restraint systems has been growing, some of the manufacturing activities have been moved to other countries in consideration of labor costs. The displaced workers have in general been redeployed in the plant or lost through attrition. To control staffing levels, the facility makes periodic use of temporary workers.

The labor market in the area is primarily based on low wage service positions. The workers employed by the facility tend to be nontraditional production workers. Many are former construction workers. Because of the nontraditional backgrounds of the assembly workers, managers claimed that their workforce did not understand the traditional job-based pay system. They felt that the base pay system and its accompanying merit plan did not allow for frequent feedback, provided little motivation, provided little recognition for learning new skills, and was perceived as too subjective. In searching for a new approach to pay, the managers wanted to

support their current job rotation program, allow for knowledge of the full production process, increase skills among employees, promote more interest in the work, support more attention to quality and support existing teamwork.

These managers chose skill-based pay in order to reward greater job-related knowledge and work flexibility. The a priori expectations of the program included increased production, efficiency, quality, safety, and involvement. In developing the system, managers incorporated input from both corporate representatives and plant employees. Employee involvement included input toward skill identification, timing of movement within skill blocks, relative importance of skills, and the performance review process. Table 1 outlines the structural components of the resulting pay system. The four pay schedules represent four different "pay plans" on the basis of pay level, with average pay level increasing across schedules. Each schedule is composed of a number of skill families. Within each schedule are skills through which employees progress to increase individual pay. Note also that each skill block has a required minimum tenure that must be achieved before moving to the next skill block.

Table 1: Skill Based Pay System -- Hourly Wage Structure

Pay Schedule	Skill Block				
	Entry	I	II	III	IV
I	82.1%	85.5	88.9	93.7	99.2
II	86.2	91.1	95.8	101.3	107.4
III	92.4	97.9	103.3	108.8	116.3
IV	97.9	103.3	108.8	116.3	123.8
Min. Time in Skill Block Before Advancement.		13 wks	13 wks	26 wks	26 wks

cell entries: wage rate as percent of mean hourly rate.

Like the control facility, this plant actively promotes the use of teams. The emphasis in this facility is on the team's role in the production process. Management claims that the teams have decision autonomy in the production process.

The Experimental Groups. The experimental facility has in essence nine different skill-based pay plans. The "plans" can be distinguished by the production processes (e.g., cutting, sewing, assembly). While the "plans" each exist within and conform to the design of the overall plan, each can exist on a different pay schedule, and the skill blocks within each "plan" are composed of different sets of tasks. Employees are allowed to transfer among pay

schedules and "plans", but within each "plan" progress through the unique series of skill blocks and pay increments.

The Work. The facilities are matched on the basis of the production process and technology, manufacturing scheduling, job rotation, and feedback systems. Both facilities rely on sequential assembly of components of the final product within production line teams. The passive restraint system assembly is generally the attachment of small parts of a total component, while the inflatable restraint system involves a great deal of patterned sewing. The facilities are paired for this study because both systems require some amount of both sewing and small part assembly, allowing for similar work processes and production technology. Table 2 illustrates the pay schedule and associated work at the treatment facility.

Table 2: Summary of Work at Treatment Facility and Position in the Skill Based Pay Structure

Pay Schedule I

- Initiator/Adaptor (component assembly)
- Inflator (component assembly)
- Module (component assembly)
- Bag Cutting (machine patterned cutting of airbags)

Pay Schedule II

- Enhancer (component assembly)
- Bag Sewing (machine patterned sewing of airbags)

Pay Schedule III

- Canister (assembly)
- Propellant Press (assembly, grinding, blending, presses, waste handling)

Both facilities espouse some form of just-in-time manufacturing. Specifically, in the control facility procurement of raw material is on a JIT basis with weekly shipment of finished goods. JIT manufacturing at the control plant was begun in April, 1991, and in the treatment facility it was begun in October, 1991.

Both facilities have mandatory job rotation programs. At the experimental facility, rotation has been required every four hours prior to the skill based pay intervention and every two hours following skill based pay intervention. At the control facility, rotation is dependent upon a systematic evaluation of the repetitiveness of the job. Highly repetitive jobs are rotated at specific rates. Additionally, management at the control plant claims that every employee in the production process is competent in every assembly job; thus, the assembly workforce is entirely

work-assignment flexible. Conversely, task competency and rotation at the experimental facility is dependent upon the skill-unit competencies exhibited in the pay evaluation process.

Both facilities maintain constant feedback systems at each line. In general, employees are aware of scheduled production goals, quantity produced, and products lost to scrap for each production period.

The Workforce. In general, the control facility is more female (+47%), older (+7 years), and has significantly greater tenure (+9.5 years) than the experimental facility. Turnover rates are also different between the two facilities. The control facility maintains a 1.5% turnover rate, while the experimental facility maintains a 12% turnover rate (reduced from a previous 25%).

The Data

Data were retrieved from company production and accounting records. From these records, production, quality, and labor cost figures were calculated. Because of the record keeping system, it is possible to create an abbreviated monthly time series of this data (n=37 months).

Labor Cost per Part. Labor cost is measured as the actual wage expense divided by the number of good parts produced. Note that this measure excludes benefits cost. If skill based pay actually increases productivity and reduces headcount, the true labor cost savings from the program are underestimated.

Quality. Quality level is measured as the number of defective units (scrap) as a percent of total units allowed through the production process.

Productivity. Where the data are available from the treatment facility, productivity is assessed as labor hours per part.

Injury. Injury frequency is measured as the number of OSHA recordable injuries during the period per employee. Injury severity is measured as the number of days lost to injury during the period per employee.

Flexibility. Potential flexibility is measured as the weighted average of employees at incremental skill levels in the pay program.

Controls. Temporary Workers refers to the proportion of the total number of workers at the treatment facility who are temporary or transient employees. JIT refers to the time period in either facility when some form of just in time process is being used. Equipment Change refers to the time period when any manufacturing group modifies or replaces existing equipment in such a way as may affect productivity or quality. Layoff is a dummy indicator of those months when a significant reduction in staff occurred at the control facility. Job Rotation is an indicator of the time period when a job rotation program is in effect at the control facility. Transition Period is an

indicator of the first five months of ownership of the treatment facility. Pay Adjustment is a dummy indicator of the month when a general cost of living adjustment is made at the treatment facility. Quality Task Force (treatment and control) is an indicator of the time period in which the treatment or control facility utilizes a task force on quality to reduce scrap amounts. Average Wage is the actual total wage expense for the period divided by the total number of labor hours for the period.

The Research Design and Analysis

Table 3 is a summary of the research design used in this study. All of the data are monthly time series. Five of the series include both pre and post intervention observations. Three of the series include control group observations for analysis of covariance between the series. Each of the production groups in the treatment facility generally represents one series. These series are pooled, and when possible pooled with a single aggregate series from the control facility. When group level data are not available, a single aggregate series is used for the treatment facility. The table also indicates that two modeling methods are used in this study. Generalized least squares is used in those cases where autocorrelation is indicated by Durbin Watson statistics. The process used employs an iterative approach to calculate a weighting matrix of the serial relationships in the error structure. Ordinary least squares is used for examining linear relationships when no violations of the model are evident.

Table 3: Research Design

<u>Outcome</u>	<u>Pre</u>	<u>Post</u>	<u>Control</u>	<u>Groups</u>	<u>N</u>	<u>Months</u>	<u>Model</u>
Flexibility		X		1	17	17	GLS
Productivity	X	X		9	333	37	GLS
Quality-Scrap	X	X	X	6	243	37	OLS
Labor Cost	X	X		1	37	37	GLS
Injury-Freq.	X	X	X	2	74	37	OLS
Injury-Sev.	X	X	X	2	74	37	OLS

* Pre = time period prior to intervention
 Post = time period following intervention
 Control = design includes a control facility
 Groups = number of experimental groups analyzed
 N = number of observations
 Months = maximum number of periods in time series
 Model = analysis method

Table 4 is a timeline of the intervention, the period over which data was gathered, and the events besides the skill based pay intervention that a priori might be thought to influence analysis results.

Table 4: Timeline of Intervention and Events

1984	Company purchases control facility.
1989	Company purchases treatment facility.
9/90	Quality task force initiated to reduce scrap (treatment).
9/90	Equipment change in work group three.
2/91	Implementation of skill-based pay.
2/91	General pay increase at treatment facility.
4/91	JIT introduced into part of control facility.
6/91	Equipment change in work group two.
6/91	Quality task force initiated (control facility).
7/91	Equipment change in work group one.
10/91	JIT introduced into treatment facility.
11/91	1st layoff at control facility.
1/92	2nd layoff at control facility.
2/92	General pay increase at treatment facility.

The analysis of this data is a least squares model in the form:

$$OUT_{it} = \alpha + (\beta_k TREAT_{it} + \beta_k GROUP_{it} + (\beta_k TREAT*GROUP)_{it} + \beta_k CONTROLS_{it} \quad (1)$$

OUT_{it} = outcome measure $TREAT$ = dummy indicator of treatment period (post SBP = 1)

$GROUP$ = dummy indicator of experiment group

$CONTROLS$ = temporary workers, JIT-treatment, JIT-control, equipment change, layoff, job rotation, transition period, pay adjustments, and quality task force (where appropriate)

The variables, $TREAT$ and $GROUP$, take on a value of one for the observations in the treatment period and experimental group, respectively, zero otherwise. The interaction ($TREAT*GROUP$) reflects a net change in the experimental group relative to the control group over time.

The dummy indicators in the model are controls for differences among the plants that could affect the outcomes aside from the treatment. First, the control facility experienced two important layoffs during the series. Indicators in the model should account for any shocks to the outcome from changes in behavior, adjustments to working with a reduced staff, or changes in output per worker. Second, each facility initiated JIT manufacturing processes into their plants at a different time during the series. A pair of indicators should reflect any resulting change in the outcomes due to the change in the production process. Third, the experimental facility made use of temporary workers during the series. These workers did not experience the same treatment and could conceivably bias any effect estimates.

Fourth, the data from the experimental facility is in the form of outcomes by production lines. This form of data allows for pooling across lines (i) over time (t). Finally, three dummy indicators are used to control for the introduction of new production equipment in three of the experimental groups.

In some cases data are not available from the control facility or is in a form incompatible with treatment facility data. The model then reduces to a single interrupted series.

$$\text{OUT}_{it} = \alpha + \beta_k \text{TREAT}_{it} + \beta_k \text{CONTROLS}_{it} \quad (2)$$

OUT = outcome measure

TREAT = dummy indicator of treatment period (post SBP = 1)

CONTROLS = temporary workers, transition period, equipment changes, and pay adjustments

In this model, the coefficient on TREAT variable is the estimated effect of the intervention. The level of analysis in these data is product group. Within the production process are lines that cut material, sew, or assemble; thus, the data is in the form of group i at time t.

Results

Data were collected from the experimental facility for all outcome measures. Depending on data availability, the observations reflect group level or aggregate data (see Table 3). The control group provided data for injury frequency and severity and for percent of scrapped units. The scrap data were for a period of five pre treatment months and the entire post treatment period.

Because the data is a pooling of multiple series across heterogeneous production process, it was necessary to standardize the outcome observations within groups to achieve meaningful results across groups. The pooled descriptive statistics and correlations are reported in Table 5. The means and standard deviations represent raw data measures. An initial examination of the correlation coefficients (correlation with the TREAT variable) suggests support for the hypotheses across all outcome variables, except the injury measures.

Table 5: Descriptive Statistics

Correlations												
Variable	Obs	Mean	s.d.	1	2	3	4	5	6	7	8	
1. Scrap %	343	1.71	3.99									
2. Lbr Hr/pt	333	0.08	0.08	0.43								
3. Treatment	370	0.46	0.50	-.25	-.55							
4. Job Rot'n.	370	0.01	0.10	-.06	0.00	0.11						
5. Flexibility	17	3.15	0.42	0.00	-.35	0.00	0.00					
6. Inj. Freq.	74	0.01	0.02	-.21	-.24	0.15	-.16	0.41				
7. Inj. Sev.	74	0.06	0.15	-.21	-.19	0.10	-.09	0.02	0.23			
8 Lbr Cst/Pt	333	0.62	0.18	0.25	0.76	-.68	0.00	-.17	.28	-.24		
9. Avg Hr Wage	333	6.85	0.68	-.26	.63	0.74	0.00	0.67	0.31	0.15	0.10	

($p < .05$: $n=17$, $r > .48$; $n=74$, $r > .24$; $n > 300$, $r > .11$)

Plots of the outcome variables over time revealed important information regarding the data. Productivity measures over time indicated that the first five period observations of the series, across experiment groups, displayed behavior unlike the following periods. Specifically, the labor hours per part were markedly higher and decreased sharply over time. These observations coincide with the first five months of new ownership of the facility by the company; thus, the outlying observations may reflect an initial adjustment period. The influence of these results would tend to provide overestimates of the treatment effect; therefore, for models including productivity or quality as the outcome measures, a dummy indicator of the five month transition period should correct for the bias. This measure was corroborated by plant personnel.

The time plots for the measures that did not include control series were examined for indications of a continuous trend unrelated to the treatment across pre/post periods and for abrupt changes in level or slope that might indicate events external to the treatment. No trends seemed prevalent across the pre/post periods, nor were any abrupt changes in level evident in the treatment series, aside from the treatment introduction and quality task force controls.

The first hypothesis regarding skill acquisition and potential flexibility increase (H1) is supported by the data. Regressing the measure of potential flexibility on the continuous indicator of time indicates that average skill level increases .06 levels each month ($p < .01$).

Table 6: Productivity and Quality as a Function of the Intervention
(outcome measures in standard deviation units)

Variable	Productivity Labor Hours/Part		Quality Scrap %	
	Coeff	s.e.	Coeff	s.e.
Intercept	0.12	0.07 *	-0.52	0.43
Treatment	-0.61	0.12 **	1.99	0.74 **
Group			0.97	0.44
Treat*Group ^a			-1.90	0.77 **
Layoff			0.17	0.70
JIT @ Trt	-0.11	0.14	-0.08	0.19
JIT @ Cont			-0.13	0.78
Temp Wkrs	0.40	0.63	-0.03 ^b	0.01 **
Equip Chg 1	-0.56	0.19 **	-0.42	0.26
Equip Chg 2	-0.40	0.18		
Equip Chg 3	0.06	0.12	0.28	0.28
Trans Per	1.55	0.14 **	0.33	0.19
Pay Adj 1	0.12	0.27	-0.29	0.38
Pay Adj 2	0.08	0.27	-0.09	0.48
Job Rot'n			-0.13	0.55
Qty Tsk Frc (T)			-0.77	0.19 **
Qty Tsk Frc (C)			-1.68	0.61 **
N	333		243	
R ²	.49 (GLS)		.25 (OLS-adj)	

^a Interaction of treatment group and intervention period.

^b Temporary workers multiplied by 100 for interpretation.

*=p<.05, **=p<.01

The second hypothesis that product quality would increase with the introduction of the skill based pay program was tested by regressing the percent of items scrapped on model (1) (Table 6). Table 7 reports the changes indicated by the results for both the treatment and control groups evaluated at the means of the controls. The predicted means and changes are calculated by multiplying the appropriate (0/1) indicator by equation coefficients (Table 6) and then transforming the standardized scores into raw percents using the relevant standard deviation (treatment, sd=.82; control, sd=1.53). Apparently, scrap at both facilities increased over time, but to a significantly smaller degree at the treatment facility. For the quality model one control variable had a significant signed coefficient in a direction opposite to the expected 1-i-e-tion. The use of temporary workers appears to have a negative effect on scrap. As expected, the use of quality committees, or task forces, had a significant negative effect on scrap percentages.

Table 7: Scrap % Evaluated at the Mean of Controls

Group	Time		Change	% Change
	Treat=0	Treat=1		
Group=0	1.540	4.587	3.048	66%
Group=1	0.523	0.596	0.074	12%

Figure 2 illustrates the change in quality over time. Especially important to note is the modeled data following the intervention. The solid line represents the actual frequencies while the shaded blocks represent the modeled outcomes. Examining Figure 2, note the declining trend in actual scrap percentages. Three levels of scrap seem evident: months 1-15 representing the period prior to the quality task force, months 16-37 representing the quality task force intervention, and months 21-37 representing the pay intervention. Modeling these outcomes note that months 1-5 indicate the transition period of the new plant. Second, months 16-21 follow the raw data closely in capturing the new level of quality. Fit of the overall model is evident by how well the modeled blocks follow the actual outcome line and by the $R^2 = .25$.

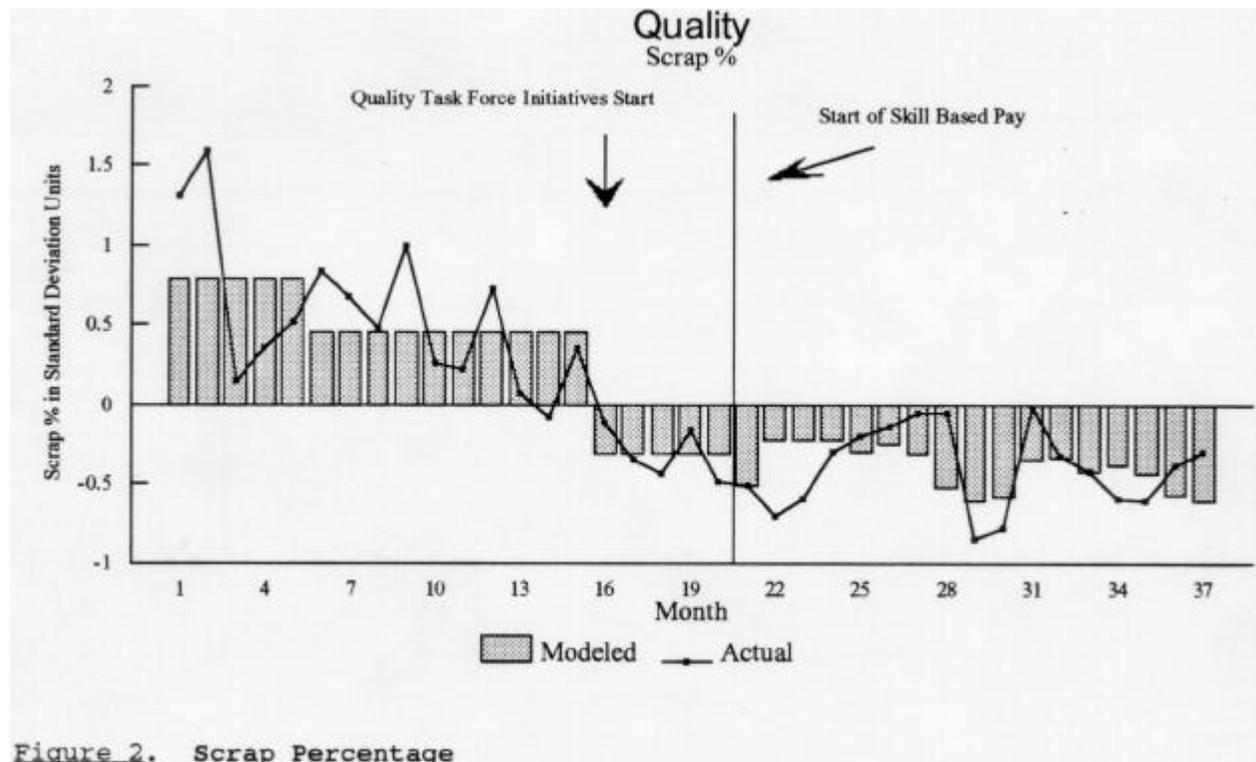
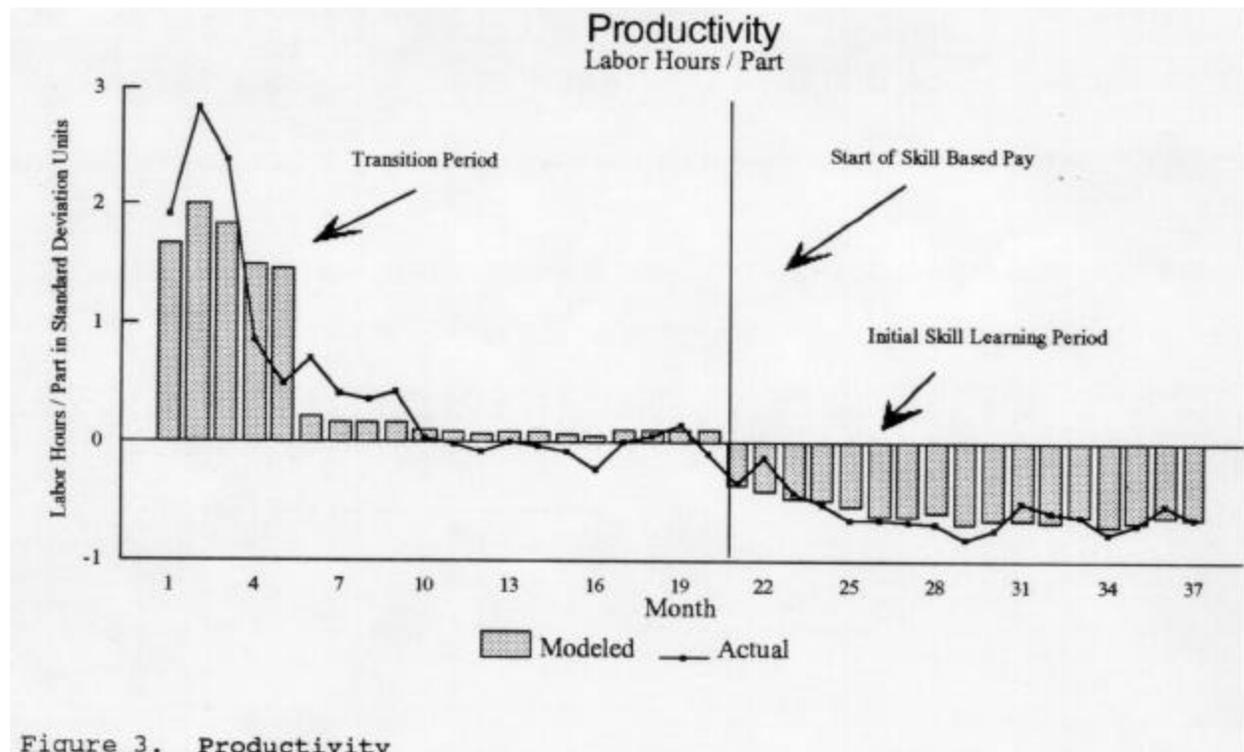


Figure 2. Scrap Percentage

To test the hypothesis that productivity increases with a skill based pay program (H3), model (2) was estimated for the variable, labor hours per part. As expected with the time series

data, Durbin-Watson statistics suggest the possibility of first order autocorrelation; therefore, generalized least squares estimates were calculated. The results, listed in Table 6, indicate a significant mean difference of $-.61$ standard deviations in labor hours between the pre and post periods, supporting the hypothesis. Transforming this result into raw labor hours ($sd=.08$) and comparing to the preintervention mean ($.10$), it is a 48% change for the facility. The signs of significant coefficients for control variables are in the expected directions. Figure 3 is a graph of this change in productivity over time. It illustrates well both the fit of the model and the decrease in labor hours per part after the intervention. Fit in this case is evident by how closely the modeled outcomes follow the observed outcomes. It is also reassuring to note that the introduction of the program did not cause an abrupt change, but rather a gradual change over time as would be expected for any changes attributed to learning.



The hypothesis that a skill based pay program is associated with a decrease in labor cost (H4) also is supported by the data (Table 8). Controlling for the transition period, a change toward a JIT production process, and the average hourly wage over time, labor cost per part produced decreased by \$.17 (a 23% change from the preintervention mean). This decrease in labor cost occurred despite increases in average hourly pay from the pay program and general

cost of living increases. Allowing the average wage to vary, the results continue to indicate a decreased cost (\$.12).

Table 8: Labor Cost per Part as a Function of the Intervention

Variable	Coeff	s.e.	Coeff	s.e.
Intercept	0.24	0.29	0.68	0.03 **
Treatment	-0.17	0.06 **	-0.12	0.05
Avg. Hourly Wage Rate	0.07	0.04		
Transition Period	0.27	0.07 **	0.22	0.06 **
JIT @ Treatment	-0.13	0.06 *	-0.13	0.06
N=37	GLS R ² =.62		GLS R ² =.61	

*p<.05, **p<.01

The final hypothesis regarding injury reduction (H5) is not supported by injury severity data and is refuted by injury frequency data (Table 9). The analysis of covariance with the control group suggests that there is actually a significant 29\$ increase in injuries per worker per month (Table 10). Examination of the data indicates that the results are heavily influenced by two months of data, month 34 for frequency and month 31 for severity. Dummy indicators in the models control for the influence of these outliers which coincide with an unusual exposure to injury (month 34) noted on the OSHA reports and to a data point estimate for missing data (month 31).

Table 9: Injury Frequency and Severity as a Function of the Intervention

Variable	Frequency		Severity	
	Coeff	s.e.	Coeff	s.e.
Intercept	0.005	0.002 **	0.005	0.025
Treatment	-0.004	0.003	-0.038	0.038
Group	0.011	0.003 **	0.073	0.036
Treat*Group	0.011	0.005 **	0.066	0.053
Month 34 outlier	0.053	0.007 **		
Month 31 outlier			0.581	0.082 **

N=74 R2 =.64 N=74 R2=.50

*p<.05, **p<.01

Table 10: Injury Frequency Evaluated at the Mean of the Control Variable

Group	Time		Change	% Change
	Treat=0	Treat=1		
Group=0	.006	.002	.004	-67%
Group=1	.017	.024	.007	+29%

Discussion

The results indicate support for hypotheses regarding both productivity and quality. The productivity results suggest a 48\$ decrease in labor hours per part. The magnitude of this result is like that found for other job design or compensation interventions (e.g., Wagner et al., 1989). The data plots indicate that this change is well modeled in the analysis and can confidently be attributed to the period of the intervention. This result may be a conservative estimate of the true effect on productivity. Typically, productivity increases as employment levels drop; however, employment increased in the control facility during the experimental period -- working against demonstrating an effect. The productivity effects are supported by both behavioral and operations theory. However, the strength and influence of competing mediating factors remains to be tested. As discussed earlier, operations research has presented evidence for a flexibility-productivity link, a structural model also including the effect of pay program on flexibility would significantly enhance the evidence.

The results regarding quality (scrap percentage) indicate support for the job design approach to understanding the relationship between pay and quality as suggested by Hackman and Oldham (1980). However, to appropriately test the mediating role of the pay-quality hypothesis, it would be necessary to measure the pay program effect on job characteristics and job characteristic effects on quality.

Like productivity and quality, labor cost decreases are supported by the data even when one considers that average hourly wage increased during the study period. Specifically, there is a \$.12 (16%) decrease in labor cost per part. This result answers the question about whether skill based pay may be more expensive because workers earn more. In this case the increase in wage is more than offset by an increase in productivity.

The remaining study hypothesis addressing injury is not supported by the data. Unexpectedly, a significant positive effect is demonstrated for injury frequency. This result provides support for an alternative hypothesis that employees working among many tasks are not as experienced and able to anticipate and avoid injury as single task employees are. The constant state of unfamiliarity and learning may create more opportunity for injury. Like previous analyses, though, this result may be indicative of the time period. As learning stabilizes and experience matures, employees may become safer workers.

In summary, the results support three important outcomes, productivity, quality and labor cost. In the case where outcomes are not supported, injury, it is likely that the time period studied influenced the results. A longer term study might provide more supportive evidence.

Limitations of the Research. Because this study is an interrupted time-series comparison of nonequivalent groups, a number of probable sources of bias or threats to validity in the results are important to consider. First, the data represent a relatively short time-series. The behavior of time-series statistics in small samples (<50) has in some cases not been tested and is expected to be less stable than statistics from large samples.

Second, in single series tests, events unrelated to the pay intervention may cause behavioral changes that affect the organizational outcomes. When possible, these events can be included in the model to control their effects. In tests including a control group series, unrelated effects should affect both groups simultaneously so that history or maturation are reflected by changes in the control group outcomes during the treatment period.

Third, both a single and control group time-series are useful for recognizing the effect of trends in organizational outcomes over time by allowing examination of the slope of outcomes prior to treatment. A related threat important to time-series is seasonality in the data. While no seasonality was expected, a priori, in this data set, cyclical outcome patterns are not evident in the pre-treatment data.

Finally, because workers were not assigned randomly to the facilities, it is possible that variables external to the treatment may affect the outcomes. These groups DIFFER on age, gender, and tenure. If an external effect is unique to any one age, gender, or tenure group, biases may be present.

The type of work conducted at each facility also may affect the validity of the results. While the work is essentially alike, the final product of each process is different. Variations in the work process may affect worker's speed or ability to learn. Related to the heterogeneity in products are the challenges to validity from any differences in product demand. While both products are in competitive markets, the growth in the inflatable restraints market may allow the company greater resources to invest in the facility, may cause scheduled production figures to be more or less achievable than in the facility with less product demand, or may affect optimism and morale among workers who are less worried about layoffs.

Management/employee relations also may be different between the plants. While structurally the work may look essentially equivalent, management's support of the process or worker's trust in management may differ between plants. If in one plant workers are more cooperative and accepting of management activities, then the productivity level may be affected to an extent different from the treatment effect. In the present study, employee trust and cooperation with management in the control facility seemed higher than could normally be expected. If this level is significantly higher than in the treatment facility, external events may

affect behavior differently between facilities and differential history or maturation effects may bias estimates.

The research design used in this study tries to address a number of threats to the internal validity of the results. The time series itself acts as its own control group, but the addition of a control series addresses additional threats to validity (Cook & Campbell, 1979). No history or maturation effects are indicated in graphical output; however, the effect of the selection of subjects into the groups is still unknown. Demographic statistics indicate differences between the groups, but any bias these differences might reflect is inestimable. However, no external influences that could not be included in the models are apparent that may have affected older workers in the control facility differentially. If they had received some form of differential compensation (e.g., early retirement benefits), then the results may be biased; however, no unaccounted for age or tenure programs were reported. Likewise, the difference in turnover would provide conservative estimates of the effects at the treatment facility. The control facility had a lower turnover and more stable workforce, while the treatment facility had greater turnover. The greater turnover would serve to constrain the effects of skill based pay by slowing movement through the pay structure and causing a lower average skill level.

This particular research design and the research results build on previous compensation research. Two important studies (Wagner, Rubin & Callahan, 1989; Hatcher & Ross, 1991) of the effect of a compensation intervention on organization outcomes both employed time series methods. Like Petty, Singleton, and Connell, the present research goes a step further by including a nonequivalent control group in the quasi-experimental design and provides support for the hypothesis that compensation interventions have significant effects on organization outcomes.

The level of generalizability of these results may be high across continuous process manufacturing environments, but may be low across other environments. Because the effect estimate reflects a pooled effect fixed across groups, the results should be generalizable to other manufacturing groups employing like tasks. The groups involved in this study performed a variety of task sets, including sewing, cutting, and assembly, for example.

The generalizability is limited though for groups such as clerical, managerial, or service because none of these skill sets were included in the present study, and may reflect very different opportunities for, or returns to, increased flexibility or enhanced job design. Another limitation is the job design used in these particular experiment and control facilities. While all groups in this study used job rotation, other facilities with similar production may not use a job design as appropriate to skill based pay and not realize the same returns. A third limitation is

suggested by the operations research literature. The results of operations studies suggest that the returns to labor flexibility differ by job-scheduling rules. Therefore, facilities using scheduling rules that maximize the returns to labor flexibility will probably realize incremental returns from implementing skill based pay over facilities using alternate rules.

A final limitation is the use of OSHA data to reflect changes in injury. OSHA data report a specific class of injuries rather than the full range of injuries. Further, they may be affected by more than actual injuries. For instance, the number of days lost may be more indicative of morale level than of injury severity. A study like this one could be enhanced by measuring and classifying many types of injuries and classifying severity in physiological terms rather than time lost. Further, attitudinal data used as a moderator to injury outcomes could enhance analyses.

Research Directions. The model tested here is not all inclusive. Many variables are candidates to affect a relationship as complex as this one (e.g., supporting organizational design, worker self efficacy, supporting operations and human resource programs, worker trust in management). The next step would be to test those moderating and mediating variables suggested in the practitioner literature and this study (e.g., growth need strength, job design), and to then identify, define, and test other contextual moderators or mediators (e.g., perceived changes in role or status). A useful outcome of this line of research might be a contingency model appropriate for guiding the management decision process in determining the appropriateness of a skill-based pay program in a specific environment.

Future research might also expand the model to include additional outcome variables. For example, analogous to pay disparity problems in job-based pay, administering skill based pay may be a potential source for discrimination. Especially in the skill acquisition and evaluation process, many opportunities exist for adverse impact. If different race, age, or gender groups acquire skills at different rates or differentially according to training method, or if different groups react differently due solely to evaluation methods, then wage gaps or differences in progression rates through the pay system may develop. The examination of discrimination might also take into account bias due to rating errors in skill certification.

Basic administrative research would also be helpful to managers in designing skill based pay programs. For example, what are optimal or appropriate numbers of skill sets to be included in programs? From the operations perspective, Park and Bobrowski (1989) report a result that may be especially relevant to skill-based pay research. They demonstrate that the greatest impact on outcome measures occurs at the lowest levels of increased flexibility, and further increments in flexibility achieve declining increments in outcome increase. In designing skill-based programs, organizations will need to consider paying for a number of new skills

relative to the cost of training the skills and the incremental benefit to organizational outcomes from the flexibility. The Jenkins et. al (1992) survey suggests that there is a wide range in the number of skill sets being used currently across organizations.

Administrative research might also ask how skill blocks should be priced to achieve internal consistency and/or external competitiveness? What are the implications of different wage setting methods?

Finally, the theories underlying this model, expectancy, activation, job characteristics, and production scheduling, represent a limited approach to a complex relationship. Competing theories may be more appropriate or provide a more parsimonious approach. Development and testing of alternate approaches would be an important contribution to compensation research.

For example, self efficacy shows promise as a useful construct. It has been linked to the rate of job learning (Morrison and Brantner, 1992), which has implications for movement through skill based pay levels. Likewise, self efficacy has been linked to setting higher goals and having greater commitment to goal achievement (Bandura, 1991; Locke and Latham, 1990; Wood and Bandura, 1989), which also has implications for skill level aspirations and attainment. Finally, many of the organizational outcomes suggested by a change to skill based pay rely on the individual workers making suggestions for changes in the production process or on changing personal behavior. Low self efficacy individuals may not perceive an ability to make useful suggestions or changes; thus, organizational outcomes may be moderated by the self efficacy levels of the workers.

An alternate theoretical approach might consider organizational justice. Valuing the individual rather than the job changes both the process of determining base pay and the distribution of base pay. The process of valuing individual skill levels may be more salient to each individual worker than job evaluation and require different levels of communication or participation. Distribution may be perceived as more or less fair depending on the comparison to different rules of equitable distribution. Under job based pay all individuals in a job may receive the same initial base pay level, while under skill based pay the formal inputs are redefined and otherwise similar individuals receive differential levels of base pay.

Finally, changes in behavior might be studied by examining changes in perceived roles. Formal roles under job based pay are often well defined by the job description and the duties that fall within the accepted boundaries of the job. Under skill based pay, the boundaries between organizational functions may become more permeable and organizational roles may become ambiguous. Status and role changes caused by a skill based pay intervention might explain some portion of any change in behavior.

Implications for Management

The results of the present study support what many managers have suspected. Skill based pay can support desired organization outcomes. This particular study has addressed productivity, quality, injuries, and labor cost. The impact on quality suggests that skill block design which includes some quality awareness component may be beneficial. Also, skill based pay may be especially important when the cost of product failure is high (e.g., nuclear reactor operation, automobile airbag production, pace maker assembly).

Increased productivity is important both because of global competition and changes in manufacturing processes. Foreign competitors are expected to garner many of the domestic low skill assembly and production jobs because they can produce units at a lower labor cost. Domestic manufacturing is expected to gravitate toward more skilled and technically complex production jobs. Both of these trends can be addressed with skill based pay. First, if less labor hours are necessary to produce a unit of output, the advantage in labor cost of foreign competitors is reduced. Second, as tasks become more complex, workers will need to be motivated to learn relevant production skills. Likewise, as rates of technological change increase, workers will need to be motivated to be flexible and expedient in skill attainment.

The results also do not support what many might expect from skill based pay. The injury rate outcomes suggest that management has a greater responsibility toward employee health and safety, especially during the skill learning period. To support any of the results, managers must realize that skill based pay is a comprehensive human resource intervention. The expectations regarding the outcomes are based on more than just a change in the way base pay is determined. A successful program also relies on adequate resource commitment to training and certification appraisal, ensuring timely and unbiased appraisals, and complementary job design and production scheduling. Missing any one of the pieces might result in either no effort toward skill acquisition or an increase in pay without the increases in productivity or quality.

Conclusion

In the short run skill based pay seems to have had a positive effect on organizational outcomes. But like many compensation interventions, these enhanced outcomes may not last. In fact, the facility in this particular study is anticipating this type of challenge and is considering gainsharing as a complementary incentive program to maintain the positive benefits of skill based pay that they have experienced. A long term study should provide evidence regarding the longevity of the outcomes and whether complementary programs, like gainsharing, may be one way to support continued returns from the intervention.

Skill based pay offers a unique approach to addressing the challenges of increased competition and rates of technological change. This study has important implications for management by estimating effect levels on important organizational outcomes. The study also challenges some expectations regarding the outcomes. It underscores the need for further testing of outcomes from skill based interventions and less reliance on prescription and perceptions of what might or should be.

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