Reporting Manufacturing Performance Measures to Workers: An Empirical Study

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Abstract: Much management accounting research has focused on the provision of periodic, aggregated financial information to managers for planning and control. Recently, many firms have adopted just-in-time production, total quality management, and teamwork practices for their manufacturing operations. These new manufacturing practices rely on increased worker involvement in the control of all phases of manufacturing, with the expectation that such involvement will result in the identification of opportunities for process innovations and manufacturing performance improvements.

The central theme of this paper is that the adoption of the new manufacturing practices necessitates changes in performance reporting and control systems. Successful implementation of these practices requires the workers to identify ways to improve the manufacturing process, reduce defects and ensure that the manufacturing operations run efficiently. Reporting manufacturing performance information provides line personnel with the feedback that is necessary for learning and directs their efforts to productivity and quality improvements. Demand for shop floor performance reporting systems is therefore likely to be greater where these new manufacturing practices are employed.

Using a sample of 362 worker responses from 40 plants, we document that the reporting of manufacturing performance measures to line personnel is positively related to the implementation of just-in-time, teamwork, and total quality management practices. Worker morale is also found to be positively related to these new manufacturing practices and to the reporting of performance information. As such, the results provide evidence on the linkage between manufacturing practices and performance reporting systems.

I. INTRODUCTION

For most of this century management accounting has focused primarily on the provision of periodic, aggregated financial information to managers for purposes of planning and control. This activity has been influenced considerably by external reporting requirements [Johnson and Kaplan 1987]. During the past decade, however, many firms have made substantial adjustments to their approaches to manufacturing that necessitate significant changes in their control systems. Milgrom and Roberts [1990], for instance, discuss how many plants are making a number of coordinated revisions in their production technology, organizational practices and

Helpful comments and suggestions by an anonymous referee and seminar participants at the University of Minnesota, the University of Wisconsin and the 1992 American Accounting Association Annual Meeting are gratefully acknowledged.
workforce management policies that shift the control of production to the line personnel on the factory floor. Production problems are not identified by managers alone, nor are solutions dictated to workers; instead workers are relied upon to come up with ways to improve process quality and productivity. Consequently, manufacturing performance information needs to be reported to shop floor personnel. In this paper, we empirically investigate the link between manufacturing practice choices and the reporting of manufacturing performance measures to shop floor personnel.

Manufacturing practices of just-in-time production (JIT) and total quality management (TQM) have recently been adopted by many Japanese and U.S. manufacturers. Moreover, many plants now emphasize teamwork and encourage their workers to solve problems and to generate innovative approaches to improve production. Studies of automobile components and other industries described in Voss [1987] emphasize the contrast in organizational practices. Traditional manufacturing plants tend to be laid out by machine or process function. Line personnel, separated from their coworkers by inventory, become specialized by repeatedly processing large batches of similar materials. Inventories are pushed through the system with quality inspections conducted by quality control personnel occurring at the end of production. In contrast, the new manufacturing practices emphasize products and customers rather than mass production. Products are grouped into cells, and workers are assigned to these cells with each employee performing several functions. Products are pulled through the system on demand. Batches are small, there is little work-in-process inventory and teams are responsible for production and quality. These new workforce management practices stress worker involvement [Zipkin 1991]. Workers learn through doing which results in improved ability to recognize problems and to implement solutions [Aoki 1986]. Reporting productivity and quality information to line personnel provides them with the feedback necessary for learning and production improvement.

A review of the recent practitioners' literature indicates that management accountants are becoming increasingly interested in the implementation of new manufacturing performance measurement systems. Some accounting practitioners are beginning to recognize that they must expand their horizons and become fully cognizant of the changes that are occurring in manufacturing if they wish to retain their position as the primary source of performance reports in organizations [Howell and Soucy 1987; Simon 1990]. The increasing attention to the need for the involvement of controllers in the reporting of operations-based performance measures rep-

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1This echoes the call by Kaplan [1983, 1984], and is reflected also in Lammert and Ehrsam [1987] and McNair and Mosconi [1987]. Kaplan [1984, p. 414] states:

Management accountants may feel that their own area of comparative advantage is to measure, collect, aggregate, and communicate financial information. This will remain a valuable mission. But it is not likely to be a goal that will be decisive to the success of their own organization, and if senior managers place too much emphasis on managing by the financial numbers, the organization's long-term viability may become threatened.

Eccles [1991] presents evidence suggesting that if accountants do not address the need for changes in reporting systems, the responsibility may be given to other staff functions.
resent a return to the origin of management accounting systems, rather than being a new task for the accountant [Johnson and Kaplan 1987].

Little is known about the factors influencing a firm's choice of a manufacturing performance reporting system [Karmarkar et al. 1987]. In this paper, we argue that this choice is influenced principally by the firm's manufacturing practices. Implementation of TQM, JIT, and teamwork practices puts the control of production in the hands of the workers, and therefore increases the value of reporting manufacturing performance information to line personnel. We test this hypothesis using questionnaire responses from 362 workers in 40 plants located in the United States.

The paper is organized as follows. In the next section we describe the new manufacturing practices and their implications for the role of manufacturing performance information. This is followed by a discussion of the research methods in Section III and empirical results in Section IV. We conclude in Section V with a discussion of the results and some suggestions for future research.

II. BACKGROUND AND HYPOTHESES

New Manufacturing Practices

In the past two decades many basic industries in the United States have faced increasing competition from foreign manufacturers. In response, many U.S. plants have begun to adopt new manufacturing practices to increase their global competitiveness. Three manufacturing practices that are increasingly being adopted by U.S. plants are total quality management (TQM), just-in-time manufacturing (JIT) and teamwork.

Total quality management, TQM, promotes involvement of the entire organization in continuously improving quality. Aspects of TQM include simplicity of product design, interaction with suppliers, and continuous upkeep of production equipment [Johnson and Kaplan 1987]. More importantly, the responsibility for detecting nonconforming items shifts from a quality control department to line personnel. Young et al. [1988] refer to this as process-based quality control, an approach in which quality is built into a product by workers as it moves through the factory. TQM makes each worker responsible for quality control and for stopping production when there is a manufacturing problem [Monden 1989]. Workers are encouraged to identify ways to improve product and process quality. Their observations on the shop floor also help fine-tune new product and process designs [Cole 1983].

Closely related to the emphasis on quality is JIT production practice. Johnson and Kaplan [1987], Maskell [1989] and Schonberger [1986] state:

\[\text{Foster and Horngren [1987, p. 25] state:}\]
\[\text{The general trends in cost control activities at both the shop level and the plant level that we have observed in JIT plants are: a declining role for financial measures, and an increasing role for personal observation and nonfinancial measures.}\]
\[\text{One reason for this trend is that production workers play a pivotal role in cost control activities. Workers directly observe nonfinancial variables on the shop floor, where they are intuitive and easy to comprehend.}\]
that manufacturing actions consistent with JIT include running production on a demand-pull basis, placing production control with workers, and streamlining the production process. Young et al. [1988] assert that a key aspect of the just-in-time/pull system is the tight relationship between production goals and current production. Implementation of JIT production is also associated with a reduction in the number of labor grades and the employment of multifunction workers.\footnote{Foster and Horngren [1987] report that one manufacturer reduced the number of labor classifications from 26 to 5 over a three year period beginning with the implementation of a JIT system.} As the holding of inventory buffers declines, greater coordination is required [March and Simon 1958]. Responsibility is therefore placed with workers and work teams to control the process, resulting in a greater demand for workers to learn multiple job skills [Monden 1989; Schonberger 1986; Foster and Horngren 1987].

The Association for Manufacturing Excellence has published several reports on another significant change in managing manufacturing operations. Many U.S. plants now encourage workers to work in teams to tackle problems on the shop floor. Workers are encouraged to pool their knowledge of the production process and come up with innovative approaches to improve productivity and quality and to reduce production lead time. Reports by Burghard [1990], Puckett and Pacheco [1990], Rhea [1987] and Rosen [1989] suggest that plants encouraging small group problem solving on the shop floor have substantially improved quality and productivity, and significantly reduced defect rates and cycle times.

Just-in-time, quality and teamwork are closely related improvement efforts that are sometimes classified together as world class manufacturing practices [Schonberger 1986; Milgrom and Roberts 1990]. A high level of quality is a prerequisite for JIT improvement efforts, otherwise production will be stopped constantly due to defective parts [Monden 1989]. Young et al. [1988] find that the potential performance benefits of just-in-time are only realized when a quality program is in place. On the other hand, JIT serves to improve quality as inventory levels are reduced and problems, which were previously hidden by inventory, are uncovered. Teamwork is essential in implementing both JIT and quality practices, as has been documented by Schonberger [1986]. Imai [1986] provides numerous examples of production teams contributing to quality improvements at Japanese plants.

The common theme of these new manufacturing approaches is the attempt to fully utilize the talents of workers on the shop floor by putting production under their control. Workers are encouraged to solve problems and improvise. In a contingency theoretic framework these approaches represent a shift from the traditional "mechanistic" organization to an evolving "organic" organization [Lawrence and Lorsch 1967]. Workers are no longer assigned to highly programmed tasks with supervision from above, rather they are encouraged to be more flexible and interactive. Respect for the worker is also cultivated under these types of production practices [Monden 1989].\footnote{Reliance on shop floor workers to control production and process improvement is in stark contrast to the more traditional bureaucratic or hierarchical systems that have been so prevalent in U.S. manufacturing firms in the twentieth century [e.g., Covaleski and Aiken 1986].} Zipkin [1991, p. 46] writes:
One of the central arguments for JIT has been that it boosts workers' morale while enlisting their efforts in the productivity improvement process. JIT has long been identified as part of the movement towards "employee involvement."

**Hypotheses**

We have argued that JIT, TQM and teamwork practices shift production control to personnel on the shop floor. Worker control is expected to increase worker morale and motivate them to contribute to process improvements and innovations. One of the primary perceived benefits of the new manufacturing practices is the gain in efficiency that occurs from the use of on-the-spot knowledge and problem solving abilities of workers [Aoki 1986]. In order for workers to identify problems and opportunities, and coordinate their efforts, management needs to provide them feedback information in the form of manufacturing performance measures."5

In *Juran's Quality Control Handbook*, Baker [1988, p. 10.28-29] states that shop floor workers in the new production systems must be provided the means for self-control: workers must have the ability to regulate their work (self-control), they must know what they are doing (feedback for learning), and they must know what they are supposed to do (goal directing information). Performance feedback to workers is necessary to enable them "to determine the relationship between their own behavior and the outcomes the process is producing." Self-control with feedback of results and knowledge of goals makes it possible for workers to discover means to improve the production process. "The freedom afforded individuals causes their creativity, intelligence, and skill to be challenged."

The necessity of feedback for learning is one of the most dependable and most studied findings in the cognitive sciences [e.g., Manis 1968]. Tversky and Kahneman [1986] assert that effective learning takes place only under certain conditions, and requires accurate and immediate feedback about the relation between the situational conditions and the appropriate response. 6 In addition, records help bolster memory, which unaided may be subject to a number of selectivity biases [Hogarth 1980].

The value of shop floor information is also consistent with organizational behavior research that has shown that feedback helps promote task oriented behavior [Ashford and Cummings 1984; Ilgen et al. 1979]. Appealing to prior goal theory research studies, Wexley and Yukl [1984] recommend that employees should have specific performance goals to guide

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5 The literature on total quality management [Deming 1986; Evahimpoour and Lee 1988; Garvin 1983, 1986; Schonberger 1986; Taguchi and Clausing 1990; Takeuchi and Quelch 1983] also suggests that firms with successful quality programs provide specific information to workers on process output. Garvin [1983] states: "Successful monitoring of quality assumes that the necessary data are available, which is not always true. Without specific and timely information on defects and field failures, improvements in quality are seldom possible." Schonberger [1986, p. 32] states: "There is substantial benefit from (shop floor information)...Information of value to the company does not stay in people's heads. It comes out and is made available so others can learn from it."

6 Tversky and Kahneman assert that a number of economic and psychological studies demonstrate that learning cannot result from monetary incentives alone. Einhorn and Hogarth [1978] discuss many of the barriers to effective learning. Goldberg [1968] lists three conditions for learning: 1) feedback, 2) the ability to rearrange cases (variation), and 3) the ability to tally the accuracy of one's hypotheses.
behavior. Johnson and Kaplan (1987), Peters and Waterman (1982, p.267) and Utzig (1988) also suggest that information can be used to promote desired employee behavior. Govindarajan and Gupta (1985) state that when perceived rewards are attached to specific performance measures, behavior is guided by the desire to optimize those performance measures. Therefore, shop floor performance information may be used to promote specific worker behavior (Daniel and Reitsperger 1991). Since the new manufacturing practices rely on the workers for process improvements, their efforts may be guided in this direction by providing them quality and productivity information.

We hypothesize therefore that the perceived value, and hence the provision of manufacturing performance information to line personnel, is positively related to just-in-time, quality, and teamwork practices.

H1: The availability of information on productivity and quality is positively related to the extent of implementation of just-in-time, quality, and teamwork programs.

The above hypothesis addresses Kaplan's suggestion that firms should provide information on productivity and quality. It is silent, however, on the form and content of such information. Quality and productivity information may include customer satisfaction surveys, field failure rates, value added per employee and other plant-wide efficiency measures. On the other hand, charts displaying defect rates, schedule compliance and machine breakdowns represent information that can be identified easily with specific production cells or work stations.

Analytic tools for process control, such as process flow charts, Pareto analysis plots, fishbone charts, histograms, run diagrams, control charts and scatter diagrams also require the posting of specific performance information on the shop floor (Ishikawa 1972; Schonberger 1986, Chapter 7). As workers acquire greater responsibility in the new manufacturing environment to control their production schedules and to inspect their own output, posting of such charts becomes important for providing them with the necessary feedback information. Therefore, we also test a detailed hypothesis concerning the provision of visual chart information about specific shop floor operations.

H2: The posting of charts about defects, schedule compliance and machine breakdown on the shop floor is positively related to the extent of implementation of just-in-time, quality and teamwork programs.

Finally, we note that these new manufacturing practices rely critically on worker involvement. Klein (1989) and Zipkin (1991) note an increase in worker stress and decline in morale in some plants. Womack et al. (1990), however, find worker morale to be higher in auto assembly plants that have adopted the new practices. Clearly a drop in worker morale would argue against increases in economic efficiencies stemming from worker involvement, and forestall any potential value from reporting manufacturing performance information to workers. Therefore, we also test:

H3: Worker morale is positively related to the extent of implementation of just-in-time, quality, and teamwork programs.
III. RESEARCH METHOD

Sample Plants

The data used in this research consist of questionnaire responses from 362 workers from 40 manufacturing plants situated in the United States. To construct this database initially 60 plants were randomly selected from lists of manufacturing plants stratified to equally represent the transportation equipment, electronics and machinery industries. The plant managers were contacted by letter and telephone to solicit participation in the study. For the 42 plants that agreed to participate, questionnaires were administered to ten randomly selected workers at each plant. Two plants returned fewer than five worker surveys and are excluded from the analysis. The actual number of worker surveys returned from the 40 plants included in this study ranged from 6 to 10 per plant. The questionnaires were collected directly to ensure confidentiality of worker responses. Summary information on costs, employment, square footage and capacity utilization for the 40 plants is presented in Table 1.

Twelve of the plants were visited by the research team in the initial phase of this study. These site visits included a tour of the facility and interviews with the plant manager, quality manager, plant accountant, a production manager, a process engineer, supervisors and workers. The questionnaire instruments were also pretested during these site visits. In many of the plants that were visited, charts and graphs were displayed on the shop floor. For example, in one plant each department had bulletin boards which showed the latest production statistics. These included several different statistical process control and quality charts reporting defect rates for the parts produced by that work center, Pareto charts, cause-and-effect diagrams and run charts for certain critical parts [e.g., Deming 1986; Ishakawa 1972]. Charts displaying daily schedule compliance (planned vs. actual schedule), charts on machine breakdowns and maintenance activi-

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Table 1

Descriptive Information About Sample Plants
(n=40)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>25%</th>
<th>50%</th>
<th>75%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Plant Employment</td>
<td>638</td>
<td>779</td>
<td>182</td>
<td>419</td>
<td>715</td>
</tr>
<tr>
<td>Total Manufacturing Costs (millions)</td>
<td>$74.8</td>
<td>$81.1</td>
<td>$24.0</td>
<td>$41.1</td>
<td>$104.6</td>
</tr>
<tr>
<td>Investment in Plant and Equipment (millions)</td>
<td>$21.4</td>
<td>$19.6</td>
<td>$5.5</td>
<td>$14.6</td>
<td>$29.8</td>
</tr>
<tr>
<td>Total Plant Area (thousand square feet)</td>
<td>316</td>
<td>530</td>
<td>75</td>
<td>166</td>
<td>300</td>
</tr>
</tbody>
</table>

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Since our research focus is on manufacturing performance information provided to workers, our tests are based on worker responses. While workers were the principal informants, secondary information was collected from supervisors and managerial staff to validate worker responses.
ties, and charts pertaining to weekly productivity measures were also evident. In one plant, quality control and production information was displayed in realtime on a computer screen. It was clear that a great deal of visual information was being provided to the workers on the shop floor.

The plant visits also revealed that the extent of implementation of the new manufacturing practices varied within the plant. Most plants began the implementation for specific production cells and product groups, and gradually extended the practices to the rest of the plant. There were also differences between different production departments within plants that were not organized into cells. For example, in one plant we found the workers in the fabrication department using elaborate defects and production charts, while the workers in the final assembly department were just beginning to display these charts. The workers in the fabrication department had completed their training courses in statistical process control methods, while workers in other departments were yet to take these same courses. Because of such variations in the implementation of the new manufacturing practices within plants, we conduct our analysis at the level of individual worker responses.

Independent Variables

The independent variables in our model are the following four scale measures constructed to represent JIT, TQM, and teamwork practices, and the extent of decentralization:

1) JIT = A scale measuring use of JIT manufacturing practices.
2) TQM = A scale measuring implementation of total quality program.
3) TEAMWK = A scale measuring use of small teams for problem solving on the shop floor.
4) DECENT = A scale measuring decentralization of authority.

The first scale measures key aspects of JIT implementation from a worker's perspective: compliance to a daily production schedule and learning multiple skills. Young et al. [1988] state that a just-in-time practice maintains a tight relationship between current production and production schedule goals. Schonberger [1986] asserts that employee involvement in production and setups requires them to learn multiple skills. The quality scale (TQM) measures key aspects of a quality program: quality incentives, worker inspection of output, and stoppage of production for quality problems. Young et al. [1988] argue that key aspects of a quality program require that all work stop when there is a production problem and that workers are responsible for identifying errors. The teamwork scale (TEAMWK) measures the extent to which workers organize into small teams to solve problems encountered on the shop floor. The decentralization scale (DECENT) measures the extent to which workers can make decisions without consulting
Table 2

Scale Measures* for Manufacturing Practices

1) JIT Scale
   i) Our schedule is designed to allow time for catching up, due to production stoppages for quality problems.
   ii) Direct labor undergoes training to perform multiple tasks in the production process.
   iii) Plant employees are rewarded for learning new skills.
   iv) We usually meet the production schedule each day.

2) TQM Scale
   i) Workers are rewarded for quality improvement.
   ii) If I improve quality, management will reward me.
   iii) Production is stopped immediately for quality problems.
   iv) I inspect my own output.**

3) TEAMWK Scale
   i) During problem solving sessions, we make an effort to get all team members' opinions and ideas before making a decision.
   ii) Our plant forms teams to solve problems.
   iii) In the past three years, many problems have been solved through small group sessions.

4) DECENT Scale
   i) I can do almost anything I want without consulting my boss.
   ii) Even small matters have to be referred to someone higher up for a final answer (Reverse scale).
   iii) This plant is a good place for a person who likes to make his own decisions.
   iv) Any decision I make has to have my boss's approval (Reverse scale).
   v) There can be little action taken here until a supervisor approves a decision (Reverse scale).

*Each response is measured on a scale from "strongly agree = 5" to "strongly disagree = 1."

**Based on factor analysis this question is omitted from the scale.

their supervisors. This scale was developed and validated by Aiken and Hage [1966] to measure hierarchy of authority. Authorizing workers to make production decisions is an important aspect of these new manufacturing practices.

We examined the four scales for reliability (consistency) and validity. Reliability addresses the extent to which measures or responses are dependable, or free of error [Nunnally 1967; Kerlinger 1973]. Scale reliability is evaluated by examining Cronbach’s alpha. This coefficient is based on the correlations among the responses comprising a scale. The alpha coefficients for the manufacturing practice scales are presented in Panel A of Table 3. They range from a low of 63.5 percent for JIT to a high of 77.2 percent for TQM, consequently the scales are reliable.8

8Nunnally [1967] states that alpha coefficients of 50 percent to 60 percent are sufficient for new scales. He also argues that increasing reliability beyond 80 percent is often wasteful for basic research.
Table 3
Reliability and Validity Tests of Manufacturing Practice Scales

<table>
<thead>
<tr>
<th>Panel A. Reliability and Construct Validity Statistics</th>
<th>JIT</th>
<th>TQM</th>
<th>TEAMWK</th>
<th>DECENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cronbach’s Alpha</td>
<td>.635</td>
<td>.772</td>
<td>.701</td>
<td>.739</td>
</tr>
<tr>
<td>Proportion of Variance</td>
<td>.476</td>
<td>.632</td>
<td>.611</td>
<td>.479</td>
</tr>
<tr>
<td>Loading on largest Factor</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Panel B: Consistency Statistics</th>
<th>JIT</th>
<th>TQM</th>
<th>TEAMWK</th>
<th>DECENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variation in Worker Responses Explained by Plant Effect</td>
<td>.275**</td>
<td>.486**</td>
<td>.338**</td>
<td>.296**</td>
</tr>
<tr>
<td>Spearman (and Pearson) Correlation Between Average Worker and Supervisor/Manager Responses</td>
<td>.603** (.550)**</td>
<td>.743** (.763)**</td>
<td>.709** (.697)**</td>
<td>.478** (.616)**</td>
</tr>
</tbody>
</table>

Pearson correlations are in parentheses.

<table>
<thead>
<tr>
<th>Panel C: Pearson Partial Correlations (After Industry Control) for Criterion-Related Validity</th>
<th>JIT</th>
<th>TQM</th>
<th>TEAMWK</th>
<th>DECENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cycle Time</td>
<td>-.336*</td>
<td>-.183</td>
<td>-.223</td>
<td>-.125</td>
</tr>
<tr>
<td>Supplier Certification</td>
<td>.418**</td>
<td>.356*</td>
<td>.157</td>
<td>.472**</td>
</tr>
<tr>
<td>Rework</td>
<td>-.281</td>
<td>-.351*</td>
<td>.131</td>
<td>.008</td>
</tr>
</tbody>
</table>

Cycle time = Logarithm of number of days from receipt of raw materials until customer receipt of product.
Supplier Certification = Percent of suppliers that are certified.
Rework = Percent of products requiring rework at final inspection.

<table>
<thead>
<tr>
<th>Panel D: Spearman (and Pearson) Correlation with Responses of Supervisors, Plant Managers, and Production Personnel</th>
<th>JIT</th>
<th>TQM</th>
<th>TEAMWK</th>
<th>DECENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>JIT Production</td>
<td>-.380** (.388)**</td>
<td>.322*</td>
<td>.549**</td>
<td>.088</td>
</tr>
<tr>
<td>Kanban Pull System</td>
<td>.251</td>
<td>.243</td>
<td>.171</td>
<td>.005</td>
</tr>
<tr>
<td>Authorization for Quality Problems</td>
<td>.276*</td>
<td>.368**</td>
<td>.405**</td>
<td>.214</td>
</tr>
<tr>
<td>Worker Control</td>
<td>.240</td>
<td>.199</td>
<td>.504**</td>
<td>.343*</td>
</tr>
<tr>
<td></td>
<td>(.159)</td>
<td>(.002)</td>
<td>(.346)*</td>
<td>(.418)*</td>
</tr>
<tr>
<td>Employee Involvement</td>
<td>JIT</td>
<td>TQM</td>
<td>TEAMWK</td>
<td>DECENT</td>
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<tr>
<td>-------------------------------</td>
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</tr>
<tr>
<td></td>
<td>.454**</td>
<td>.411**</td>
<td>.660**</td>
<td>.289*</td>
</tr>
<tr>
<td></td>
<td>(.409)**</td>
<td>(.361)*</td>
<td>(.610)**</td>
<td>(.431)**</td>
</tr>
</tbody>
</table>

Pearson correlations are in parentheses.
*Indicates significant at 5% level (one-tail).
**Indicates significant at 1% level (one-tail).

JIT Production = Response of supervisors, process engineer and plant production manager to question "all major department heads within the plant work towards encouraging just-in-time production."

Kanban Pull System = Response of supervisors, process engineer and plant production manager to the question "we use a Kanban pull system for production control."

Authorization for Quality Problems = Response of supervisors, process engineer and plant production manager to the question "direct labor is authorized to stop production for quality problems."

Worker Control = Response of plant production manager to the statement "production control is in the hands of workers."

Employee Involvement = Response of supervisors, process engineer and plant production manager to the question "our top management strongly encourage employee involvement in the production process."

Each question is measured on a five-point Likert scale where "strongly agree = 5" and "strongly disagree = 1."

While the responses of workers at the same plant may differ due to varying involvement in key aspects of the manufacturing practices implemented in different parts of the plant, there is likely to be some consistency between the responses from the same plant. The percentage of variation in worker responses explained by the plant effect ranged from 27.5 percent for JIT to 48.6 percent for TQM, the plant effect was highly significant (p < .001) for all four scales. We also compared the average worker response at each plant with the average of responses of two/three supervisors from the same plant. The results presented in Panel B of Table 3 indicate that all the correlations are highly significant (p < .001), ranging between .478 for DECENT and .743 for TQM.

We evaluated the practice scales for content validity, construct validity, and criterion-related validity [Kerlinger 1973]. Content validity is strived for by constructing questions that represent key aspects of the new manufacturing practices. We have discussed earlier why the scales represent essential attributes of the new manufacturing practices from a worker's perspective. Construct validity is supported by factor analysis. Panel A of Table 3 reports that each scale loads on one factor with the percentage of the variation explained by that factor ranging from 47.6 percent for JIT to 63.2 percent for TQM.\(^9\)

Criterion-related validity is evaluated by examining Pearson partial correlations between the manufacturing practice scales and three other vari-

\(^9\)The TQM scale question #4, "I inspect my own output," is dropped based on factor analysis. From this point forward, all measures of the TQM scale exclude question #4.
ables that are expected to be highly correlated with the practices. Partial correlations are used to examine the correlations after controlling for industry representation. The criterion variables are plant-wide measures of cycle time (in days), percent of units requiring rework and percent of suppliers certified. Cycle time is chosen because a key benefit of JIT is the reduction of inventories. Reduction of rework requirements is a primary goal of quality improvement programs and supplier certification is expected to improve input quality and facilitate JIT production. Because these three variables are measured at the plant level, the responses of workers from a particular plant are averaged for this analysis. These correlations are presented in Panel C of Table 3. With the exception of the insignificant positive partial correlation between DECENT and rework, and TEAMWK and rework, all correlations are in the expected direction and five are significant at the 5 percent level. We also compare our new manufacturing practice variables with the responses of plant management to workforce related questions in Panel D of Table 3. The practice scales are strongly related to managers' perceptions of JIT production, authorization for quality problems, worker control and employee involvement. This suggests that our scale measures based on worker responses are capturing important attributes of the new manufacturing practices in place at plants.

**Dependent Variables**

Measures of availability of information and level of morale were also solicited from workers in the questionnaire surveys. All of these questions are presented in Table 4. Similar to the independent variables, each question was measured on a five point Likert scale, where responses ranged from "strongly agree = 5" to "strongly disagree = 1." The first two information availability questions correspond to recommendations by Kaplan (1983) that information on quality and productivity should be compiled and reported to employees. The last three represent specific types of charts that are posted on the shop floor for feedback purposes. Each worker also responded to six questions that are compiled into a scale representing worker morale. This scale is constructed from a subset of Mowday and Steer's (1979) commitment scale. The scale appears to have reliability and construct validity as the alpha coefficient is 83.9 percent and the largest factor explains 56.7 percent of the variation.

The percentage of variation in worker responses that is explained by the plant effect ranged from 22.4 percent for machine breakdown charts to 34.5 percent for defects charts, all significant at the .001 level. Average worker responses are consistent with average supervisor/manager responses from the same plant. All correlations are highly significant, and range from .338 for machine breakdown charts to .729 for defects charts (see Table 5).

**Estimation Model**

The following system of equations portrays the hypothesized relationships between the dependent variables and the new manufacturing practices:

\[ Y_{jw} = \alpha_j + \sum_{i=1}^{4} \beta_{ij} X_{iw} + \varepsilon_{jw}, \]  

(1)
Table 4
Description of Dependent Variables

Quality and Productivity Information Availability
1. Quality = Information on quality performance is readily available to employees.
2. Productivity = Information on productivity is readily available to employees.

Posting of Charts on the Shop Floor
3. Defects = Charts showing defects are posted on the shop floor.
4. Schedule = Charts showing schedule compliance are posted on the shop floor.
5. Machine = Charts plotting the frequency of machine breakdowns are posted on the shop floor.

Worker Morale
6. Worker Morale Scale:
   i) I am willing to put in a great deal of effort beyond that normally expected.
   ii) I talk up this organization to my friends as a great organization to work for.
   iii) I would accept almost any type of job assignment in order to keep working for this organization.
   iv) I am proud to tell others I am part of this organization.
   v) This organization really inspires the best in me in the way of job performance.
   vi) I am really glad I chose this organization to work for over others.

*Each variable is measured on a five point Likert scale ranging from "strongly agree = 5" to "strongly disagree = 1."

**Cronbach alpha is .839 and percent of variation explained by the largest factor is .567.

where:
Y = quality information, productivity information, defects charts, schedule compliance charts, machine breakdown charts, and worker morale, \( j = 1, \ldots, 6; \)
X = JIT, TQM, TEAMWK, DECENT, \( i = 1, \ldots, 4; \)
w = worker \( w, w = 1, \ldots, 362. \)

Two issues had to be resolved in order to estimate the relation between the manufacturing practices and the dependent variables. One concern is the potential correlation among the error terms of workers located in the same plant. Following Johnston [1984], we specify this relationship as an errors components model. Specifically, each worker's response error, \( \varepsilon_{jw}, \) is assumed to comprise two components: \( \mu_{jp}, \) a plant-wide fixed effect term, and \( \delta_{jw}, \) an independently and identically distributed worker specific random error term, so that \( \varepsilon_{jw} = \mu_{jp} + \delta_{jw} \) for worker \( w \) in plant \( p. \) Consequently, dummy variables representing each plant are introduced into the model to account for the plant effect term.\(^{10}\)

\(^{10}\)This format also results in predictor variables that are the same across the six equations. Since the explanatory variables across equations are identical, there is no efficiency gain from jointly estimating a system of related equations [Thell 1970]. Therefore, no adjustment in OLS estimates is necessary for the potential correlation among the six responses of the individual worker.
<table>
<thead>
<tr>
<th></th>
<th>Quality Information</th>
<th>Productivity Information</th>
<th>Defects Charts</th>
<th>Schedule Compliance Charts</th>
<th>Machine Breakdown Charts</th>
<th>Worker Morale Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variation in Worker Responses Explained by Plant Effect</td>
<td>.300**</td>
<td>.276**</td>
<td>.345**</td>
<td>.239**</td>
<td>.224**</td>
<td>.294**</td>
</tr>
<tr>
<td>Spearman (and Pearson) Correlations Between Average Worker and Supervisor/Manager Responses</td>
<td>.430**</td>
<td>.590**</td>
<td>.729**</td>
<td>.390**</td>
<td>.338**</td>
<td>.665**</td>
</tr>
<tr>
<td></td>
<td>(.455)**</td>
<td>(.590)**</td>
<td>(.735)**</td>
<td>(.405)**</td>
<td>(.380)**</td>
<td>(.603)**</td>
</tr>
</tbody>
</table>

Pearson correlations are in parentheses.
"**"Indicates significant at 1% level (one-tail).
\[ Y_{jw} = \alpha_j + \sum_{i=1}^{4} \beta_{ij} X_{iw} + \sum_{p=1}^{39} \mu_{jp} D_{pw} + \delta_{jw}. \]  

where \( D_{pw} = 1 \) if worker \( w \) is in plant \( p \), and = 0 otherwise. Industry differences can be examined by comparing the average plant effect terms by industry.

A second issue is that the worker responses to the survey questions are ordered categorical variables [Maddala 1983]. While the worker morale scale is the average of six responses and approaches a continuous variable (takes on 25 possible values), the worker responses to the dependent variables concerning shop floor information can take on only five discrete values. Following Maddala [1983, pp. 46-49] and Cox and Snell [1989, pp. 158-161] we also estimate the parameters using a maximum likelihood nonlinear ordered polychotomous logit estimation routine. The left hand side of the estimation model in (2) now represents the proportional odds for each ordinal level [McCullagh 1980]. These estimates are consistent and asymptotically, normal and efficient. We construct likelihood ratio tests for overall model fit, and employ a measure of goodness-of-fit, \( R^2 = 1 - \frac{\text{likelihood ratio}}{\text{likelihood ratio}} \), suggested by Maddala [1983, p. 39]. The results of this estimation are presented in Table 9 for comparison with OLS estimates reported in Table 8.

IV. EMPIRICAL RESULTS

Descriptive Statistics

Summary information on the explanatory variables is presented in Table 6. Panel A indicates that the means of the scale predictor variables range from a low of 2.91 for TQM and DECENT to a high of 3.42 for TEAMWK. The mean JIT response is close to that of TQM at 2.97. The quartiles and standard deviation information indicates that all four scales have a similar degree of variation. Spearman and Pearson correlations are reported in Panel B of the table. The correlations document significant positive associations among the variables representing the new manufacturing practices of JIT, TQM and TEAMWK. This is expected, given that just-in-time, quality and teamwork programs are complementary practices that are sometimes grouped together as world class manufacturing practices. The significant positive association with the decentralization variable is also consistent with the view that the new manufacturing practices give line personnel more control over the day-to-day operations.

Summary data on the dependent variables are presented in Table 7. The Panel A univariate statistics reveal that average worker responses for the availability of quality and productivity information are greater than the average responses for the posting of charts for defects, schedule compliance and machine breakdowns. Having a chart on defects or schedule compliance on the shop floor is likely to be a subset of the information on

---

11 The parameters are estimated using the PROC LOGIST procedure in SAS.
12 The measure may understate the goodness-of-fit as its upper bound is strictly less than one [Maddala 1983].
Table 6
Descriptive Information on the Manufacturing Practice Scales (n=362)

Panel A. Summary Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>25%</th>
<th>50%</th>
<th>75%</th>
</tr>
</thead>
<tbody>
<tr>
<td>JIT</td>
<td>2.97</td>
<td>.70</td>
<td>2.50</td>
<td>3.00</td>
<td>3.50</td>
</tr>
<tr>
<td>TQM</td>
<td>2.91</td>
<td>.75</td>
<td>2.33</td>
<td>3.00</td>
<td>3.67</td>
</tr>
<tr>
<td>TEAMWK</td>
<td>3.42</td>
<td>.81</td>
<td>3.00</td>
<td>3.67</td>
<td>4.00</td>
</tr>
<tr>
<td>DECENT</td>
<td>2.91</td>
<td>.75</td>
<td>2.40</td>
<td>3.00</td>
<td>3.40</td>
</tr>
</tbody>
</table>

Panel B: Correlation Matrix

<table>
<thead>
<tr>
<th></th>
<th>JIT</th>
<th>TQM</th>
<th>TEAMWK</th>
<th>DECENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>JIT</td>
<td>1.000</td>
<td>.511*</td>
<td>.415*</td>
<td>.150*</td>
</tr>
<tr>
<td>TQM</td>
<td>.509*</td>
<td>1.000</td>
<td>.342*</td>
<td>.096</td>
</tr>
<tr>
<td>TEAMWK</td>
<td>.422*</td>
<td>.375*</td>
<td>1.000</td>
<td>.240*</td>
</tr>
<tr>
<td>DECENT</td>
<td>.141*</td>
<td>.123*</td>
<td>.266*</td>
<td>1.000</td>
</tr>
</tbody>
</table>

Spearman correlations are above the diagonal, Pearson correlations are below the diagonal.
**Indicates significant at 5% level.

quality or productivity that is available to the worker. The availability of machine breakdown charts is much lower than the availability of defect and schedule compliance charts, suggesting that reporting information on breakdowns may depend on the machine maintenance policy of the plant. Panel B of Table 7 presents pairwise Spearman and Pearson correlations between the dependent variables. The significant correlations suggest that all of the information variables are driven by similar economic factors. Worker morale is also positively related to each of the workers' information responses.

Hypotheses Tests

The results of the regressions relating quality and productivity information, posting of charts and worker morale to the new manufacturing practices are presented in Tables 8 and 9. The estimation results with the polychotomous ordered logit model are very similar to the OLS results, and therefore we only discuss the OLS results here. All of the regressions in Table 8 are significant. The amount of variation in the worker responses that can be explained by the predictor variables ranges from 32.8 percent to 52.3 percent.

The most striking result across all the regressions is the consistency of the sign on each predictor variable's coefficient. The parameter estimates

13Influential observation analysis was conducted using the RSTUDENT, COVRATIO, h, and DFFITS statistics of Belsley et al. [1980]. OLS regressions were re-estimated after dropping observations that exceeded two or more of the thresholds identified by Belsley et al. The (Contined on page 52)
### Table 7
Descriptive Information for the Dependent Variables
(n=362)

#### Panel A. Summary Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>25%</th>
<th>50%</th>
<th>75%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality Information</td>
<td>3.52</td>
<td>1.07</td>
<td>3.00</td>
<td>4.00</td>
<td>4.00</td>
</tr>
<tr>
<td>Productivity Information</td>
<td>3.59</td>
<td>1.01</td>
<td>3.00</td>
<td>4.00</td>
<td>4.00</td>
</tr>
<tr>
<td>Defects Charts</td>
<td>3.29</td>
<td>1.28</td>
<td>2.00</td>
<td>4.00</td>
<td>4.00</td>
</tr>
<tr>
<td>Schedule Compliance Charts</td>
<td>3.28</td>
<td>1.13</td>
<td>2.00</td>
<td>3.00</td>
<td>4.00</td>
</tr>
<tr>
<td>Machine Breakdowns Charts</td>
<td>2.34</td>
<td>1.05</td>
<td>2.00</td>
<td>2.00</td>
<td>3.00</td>
</tr>
<tr>
<td>Worker Morale Scale</td>
<td>3.71</td>
<td>.72</td>
<td>3.33</td>
<td>3.83</td>
<td>4.16</td>
</tr>
</tbody>
</table>

#### Spearman Correlations

<table>
<thead>
<tr>
<th>Variable</th>
<th>Quality Information</th>
<th>Productivity Information</th>
<th>Defects Charts</th>
<th>Schedule Compliance Charts</th>
<th>Machine Breakdown Charts</th>
<th>Worker Morale Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality Information</td>
<td>1.00</td>
<td>.480*</td>
<td>.428*</td>
<td>.374*</td>
<td>.288*</td>
<td>.317*</td>
</tr>
<tr>
<td>Productivity Information</td>
<td>.472*</td>
<td>1.00</td>
<td>.340*</td>
<td>.330*</td>
<td>.260*</td>
<td>.387*</td>
</tr>
<tr>
<td>Defects Charts</td>
<td>.421*</td>
<td>.346*</td>
<td>1.000</td>
<td>.348*</td>
<td>.346*</td>
<td>.310*</td>
</tr>
<tr>
<td>Schedule Compliance Charts</td>
<td>.375*</td>
<td>.345*</td>
<td>.358*</td>
<td>1.000</td>
<td>.227*</td>
<td>.288*</td>
</tr>
<tr>
<td>Machine Breakdown Charts</td>
<td>.292*</td>
<td>.279*</td>
<td>.372*</td>
<td>.244*</td>
<td>1.000</td>
<td>.249*</td>
</tr>
<tr>
<td>Worker Morale Charts</td>
<td>.295*</td>
<td>.368*</td>
<td>.291*</td>
<td>.275*</td>
<td>.214*</td>
<td>1.000</td>
</tr>
</tbody>
</table>

Spearman correlations are above the diagonal, Pearson correlations are below the diagonal.

*Indicates significant at 5% level.
Table 8
OLS Regression Estimates Relating Manufacturing Performance Reports and Worker Morale to the Manufacturing Practices (Absolute t-values in parentheses, n=362)

\[ Y_{pw} = \alpha_j + \beta_{1j}JIT_w + \beta_{2j}TQM_w + \beta_{3j}TEAMWK_w + \beta_{4j}DECENT_w + \sum_{p=1}^{39} \gamma_{jp} D_{pw} + \delta_{jw} \]

<table>
<thead>
<tr>
<th>Variable</th>
<th>Quality Information</th>
<th>Productivity Information</th>
<th>Defects Charts</th>
<th>Schedule Compliance Charts</th>
<th>Machine Breakdown Charts</th>
<th>Worker Morale Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>JIT</td>
<td>.143 (.158)</td>
<td>.237** (.283)</td>
<td>.383** (3.58)</td>
<td>.205* (2.03)</td>
<td>.396** (4.31)</td>
<td>.316** (5.78)</td>
</tr>
<tr>
<td>TQM</td>
<td>.339* (.345)</td>
<td>.324** (.359)</td>
<td>.097 (.84)</td>
<td>.290** (2.03)</td>
<td>.316** (3.18)</td>
<td>.126* (2.14)</td>
</tr>
<tr>
<td>TEAMWK</td>
<td>.225** (.277)</td>
<td>.243** (.323)</td>
<td>.015 (.84)</td>
<td>.186* (2.04)</td>
<td>.062 (.76)</td>
<td>.254** (5.17)</td>
</tr>
<tr>
<td>DECENT</td>
<td>.060 (.79)</td>
<td>.080 (.114)</td>
<td>.288** (3.21)</td>
<td>.156* (1.83)</td>
<td>.039 (.51)</td>
<td>.022 (.48)</td>
</tr>
<tr>
<td>R²</td>
<td>.399</td>
<td>.422</td>
<td>.414</td>
<td>.332</td>
<td>.350</td>
<td>.518</td>
</tr>
<tr>
<td>F (model)</td>
<td>4.927</td>
<td>5.408</td>
<td>5.242</td>
<td>3.690</td>
<td>3.994</td>
<td>7.962</td>
</tr>
<tr>
<td>p (model)</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>F (plant coef.)</td>
<td>2.638</td>
<td>2.200</td>
<td>4.233</td>
<td>2.410</td>
<td>2.310</td>
<td>2.275</td>
</tr>
<tr>
<td>p (plant coef.)</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

*Indicates significant at 5% level.
**Indicates significant at 1% level.
Table 9
Polychotomous Logit Regression Estimates Relating Manufacturing Performance Reports and Worker Morale to Manufacturing Practices
(Absolute z-statistics in parentheses, n = 362)

\[
\log \left( \frac{\theta_{jkw}}{1-\theta_{jkw}} \right) = \alpha_j + \beta_{j1}JIT_w + \beta_{j2}TQM_w + \beta_{j3}TEAMWK_w + \beta_{j4}DECENT_w + \sum_{p=1}^{39} \gamma_{jp} D_{pw} + \delta_{jw}
\]

<table>
<thead>
<tr>
<th>Variable</th>
<th>Quality Information</th>
<th>Productivity Information</th>
<th>Defects Information</th>
<th>Schedule Compliance Charts</th>
<th>Machine Breakdown Charts</th>
<th>Worker Morale Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>JIT</td>
<td>.456*</td>
<td>.702**</td>
<td>.742**</td>
<td>.423*</td>
<td>.877**</td>
<td>1.152**</td>
</tr>
<tr>
<td></td>
<td>(2.23)</td>
<td>(3.21)</td>
<td>(3.74)</td>
<td>(2.20)</td>
<td>(4.31)</td>
<td>(6.15)</td>
</tr>
<tr>
<td>TQM</td>
<td>.660**</td>
<td>.765**</td>
<td>.145</td>
<td>.594**</td>
<td>.694**</td>
<td>.463**</td>
</tr>
<tr>
<td></td>
<td>(3.00)</td>
<td>(3.32)</td>
<td>(.68)</td>
<td>(2.84)</td>
<td>(3.18)</td>
<td>(2.33)</td>
</tr>
<tr>
<td>TEAMWK</td>
<td>.517**</td>
<td>.640**</td>
<td>.105</td>
<td>.353*</td>
<td>.186</td>
<td>.933**</td>
</tr>
<tr>
<td></td>
<td>(2.82)</td>
<td>(3.01)</td>
<td>(.59)</td>
<td>(1.95)</td>
<td>(1.03)</td>
<td>(5.37)</td>
</tr>
<tr>
<td>DECENT</td>
<td>.068</td>
<td>.068</td>
<td>.593**</td>
<td>.372*</td>
<td>.114</td>
<td>.085</td>
</tr>
<tr>
<td></td>
<td>(.38)</td>
<td>(.37)</td>
<td>(3.50)</td>
<td>(2.27)</td>
<td>(.69)</td>
<td>(.55)</td>
</tr>
<tr>
<td>R²*</td>
<td>.401</td>
<td>.435</td>
<td>.407</td>
<td>.328</td>
<td>.337</td>
<td>.523</td>
</tr>
<tr>
<td>χ² (model)</td>
<td>185.5</td>
<td>206.7</td>
<td>189.7</td>
<td>144.3</td>
<td>149.3</td>
<td>268.2</td>
</tr>
<tr>
<td>p (model)</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>χ² (plant coef.)</td>
<td>102.2</td>
<td>93.9</td>
<td>145.0</td>
<td>91.7</td>
<td>79.3</td>
<td>81.1</td>
</tr>
<tr>
<td>p (plant coef.)</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

*Indicates significant at 5% level.
**Indicates significant at 1% level.
*The goodness-of-fit measure $R^2 = 1 - (\text{likelihood ratio})^{2/n}$ is computed as in Maddala (1983, p. 39).
for the predictor variables do not reverse signs across equations. The statistical significance of the individual coefficients does vary by type of nonfinancial information. The JIT, TQM and TEAMWK scale-measures exhibit strong positive association with the likelihood that information on quality and productivity is provided to workers. DECENT is not significantly related to the provision of this information. All of the predictor variables are significantly related to the posting of schedule compliance charts, while only JIT and TQM are significantly related to the provision of machine breakdown charts. The regression result for defects charts indicates that provision of such information is significantly related to JIT and DECENT. Information on defects might be expected to be more closely related to TQM than to the other manufacturing practices. Recall, however, that the pairwise correlation between JIT and TQM is 51 percent. On re-estimating the defects regression in Table 8 after excluding the JIT variable, the coefficients on TQM and TEAMWK rise to .227 (p=.022) and .122 (p=.094), respectively. Finally, a F-test on the plant coefficients indicates that in each regression there is also a significant plant effect. A comparison of average plant effects, however, does not reveal a significant difference between industries.

Table 8 also presents evidence on the strong positive relationship between worker morale and the new manufacturing practices. In fact, over 50 percent of the variation in morale is explained by the regression variables. JIT and TEAMWK are particularly strong explanators. It contradicts the concerns expressed by Zipkin [1991] and others that workers experience lower morale with the introduction of the new manufacturing practices. This is reassuring as these practices rely on workers to identify improvement opportunities when they are given more control over the day-to-day production.

V. CONCLUDING REMARKS

This paper examines the association between just-in-time, quality, and teamwork practices and the provision of manufacturing performance information to line personnel. Because these new organizational and workforce management practices put the control of production in the hands of line personnel, we posit a positive relationship between the extent of implementation of these practices and the provision of information to workers on the shop floor. We present evidence on this relationship using a sample of 362 worker responses from 40 plants located in the United States.

Footnote 13 (Continued)

number of observations dropped ranged between 12 and 17 for the six regressions. The re-estimation increases the $R^2$ for all the regressions. The $R^2$ now range between 43 percent and 58 percent. All the earlier significant coefficients remain significant. In addition, two more coefficients become significant at the 5 percent level: the JIT coefficient in the quality regression and the TEAMWK coefficient in the machine breakdown regression.

The predictor variables are positively correlated and the evidence presented here may be best interpreted in overall terms as indicating a strong positive relation between implementation of world class manufacturing practices and provision of manufacturing performance information to workers. The Belsley-Kuh-Welsch diagnostics, however, indicate that multicollinearity is not a serious problem. The highest condition index is only 25.5, and in only one case (associated with condition index value 17.2) do the variance components for two of the independent variables (JIT .59, TQM .67) exceed .4.
Two important findings emerge from this research. First, we document that the provision of information to shop floor workers is positively related to the implementation of just-in-time, quality, and teamwork practices. As such, our results provide evidence of a link between manufacturing practices and control systems that emphasize the role of workers. This is important given that little is known about factors that influence firms' choices of performance reporting systems. Second, we establish that employee morale is positively related to the existence of just-in-time, quality, and teamwork production systems, and the provision of shop floor performance information. This finding is useful given that there have been contrary opinions expressed concerning the impact of these new practices on worker stress and morale [Klein 1989; Zipkin 1991].

This study also raises a number of questions for future research. One interesting avenue is to determine if firms that provide performance information to workers on the shop floor experience more productivity gains from the implementation of these new manufacturing practices than firms that implement these practices but do not provide shop floor performance information. Another direction for future research is to examine the attributes of manufacturing performance reporting systems that promote worker learning. While it is well known that feedback is a necessary condition for learning, the impact of different types and forms of feedback, and the timing of feedback (on learning), need to be examined in this environment. Both Hayes and Clark [1985] and Teece and Winter [1984] believe research on learning is critical for advances in modern management. We believe research on the link between manufacturing performance reporting and learning is important for modern management accounting. Future research studies may also include detailed documentation of reporting systems that have been adapted to the new manufacturing practices, and examine transition problems encountered in changing from the old to the new systems. An important research question is whether the changes in the shop floor performance reporting systems result from the workers' own initiative in the new manufacturing environment, or whether the changes are dictated by plant management and corporate accountants. Empirical research is just beginning in this important area of management accounting.
REFERENCES


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