

**An Empirical Examination of
Management Control Systems
in
Just-In-Time Manufacturing**

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We investigate whether the interactions between JIT manufacturing techniques and information systems (i.e., performance goals and attention-directing feedback) are dependent on the reward system (i.e., incentive vs. fixed pay plans). Our findings provide some support for the hypotheses. Results show by itself JIT often does not lead to performance gains. Likewise, incentive pay per se is not associated with better manufacturing performance. Instead, it is often the match between JIT and management control systems (i.e., the information and reward systems) that produces higher manufacturing performance as measured in terms of changes in manufacturing costs and warranty costs. These findings provide support for normative theory that states that control systems should be designed to encourage workers' behavior, which will increase the probability of meeting the objectives and goals of organizations.

INTRODUCTION

Since the introduction of mass production (or the assembly line approach) by Henry Ford in 1914, some manufacturers have been able to enjoy cost reduction made possible through specialization from working on standardized jobs. In a mass production system, workers are supervised closely and they usually perform a single function. Optimization tends to be achieved through smooth continuous production runs. In addition, interventions are discouraged and responsibility for quality often lies in a separate quality control department. Commentators claimed that this approach tends to reduce workers' involvement and consequently reduced job satisfaction, thereby leading to costly dysfunctional behavior. In contrast, modern manufacturing often relies on workers' cooperation and enhanced job satisfaction to overcome such dysfunctional behavior. For example, in a study of firms implementing modern manufacturing practices, Sarkar (1997) writes:

The plant managers most excited about JIT and its benefits were generally also those who could not emphasize enough, 'it's all in the people', 'getting the workers to take ownership is the key', 'making sure they have all the tools is most important, and that cooperation is everything.'

Given the amount of responsibilities assumed by workers in modern manufacturing, such as JIT, organizational control systems are often used as mechanisms to motivate and influence workers' behaviors in ways that will maximize the welfare of the organization. In fact, management accountants often stress that the best strategies will be worthless unless managers understand the tools and techniques to implement these strategies. Accordingly, the aim of the paper is to examine the type of control which will compliment modern manufacturing techniques, such as JIT, whereby leading to better manufacturing performance.

The remainder of the paper is organized as follows. The next section overviews some related literature as the basis for developing the hypotheses. The ensuing sections describe the research method and research findings. The final section discusses the results and presents implications for future research.

THEORETICAL DEVELOPMENT AND HYPOTHESES

This section reviews prior literature relevant to this study, which includes studies on JIT manufacturing techniques and management control systems. This is followed by identification of hypotheses to be tested.

JIT Manufacturing Techniques

JIT programs rely on persistence in pursuing continuous incremental improvement in manufacturing operations (Fine, 1993, p. 716; Groenevelt, 1993, p. 638; Zipkin, 1991; Delbridge et al., 1991). A vital part of every Just-in-Time manufacturing is the reduction of setup up times, lot sizes, and inventories. Smaller lot sizes lead to shorter manufacturing cycle times and indirectly help to reduce scrap and rework associated with process failure. Likewise, a lower level of buffer stock calls for ‘doing things right the first time.’ Thus, improving quality is also an important part of any JIT implementation. In a JIT environment, the task of improving manufacturing capabilities lies in the hands of workers. Responsibility for detecting non-conforming items shifts from a quality control department to line personnel. A continuous improvement philosophy calls for each worker to be responsible for quality control and for stopping the production process when there is a problem. In addition, workers are encouraged to identify ways to improve product and process quality.

Because of shorter lead time and a more transparent manufacturing process due to lower inventory, JIT allows workers to notice and correct poor quality more quickly which leads to less rework. The reduced losses will translate into lower manufacturing costs. In addition, continuous improvement in the manufacturing processes, a key feature of JIT, should lead to increased productivity. Finally, increased participation among workers and the greater autonomy delegated to workers under JIT often increase job satisfaction which in turn should lead to improved performance or higher productivity.

Despite many positive features associated with JIT implementation, research findings on JIT implementation have been mixed. For example, Inman and Mehra (1993) found a significant relationship between financial success and JIT implementation while Balakrishnan et al. 1996 found somewhat weak findings with respect to differences in return on assets between JIT and non-JIT firms.

On the other hand, Dean and Snell (1996) reported no significant relationship between JIT implementation and manufacturing performance. Similarly, Sakakibara et al. 1997 showed that there was no significant relationship between the use of JIT practices and manufacturing performance. These mixed findings, however, can be explained by some extant literatures. For example, social technical systems theory states that changes in work system can affect the cultural, behavioral, and political environment of a work place. Thus, unless complimentary changes also occur in other related systems, such as decision right system, human resource system, or reward system, the perceived productivity gain of a new work system may not be realized (Cummings and Blumberg 1987). Similarly, many organizational theorists suggest that successful implementation of advanced manufacturing systems such as JIT requires changes in management control systems (Jensen and Meckling, 1976; Holmstrom, 1979; Fama and Jensen,

1983; Jensen, 1983, Wruck and Jensen 1994; Milgrom and Roberts 1990, 1995). Accordingly, the next section addresses issues related to management control systems.

Management Control Systems

Management control systems are sets of tools used to motivate people's behavior towards the attainment of organizational goals. As a result, management accountants and organizational theorists often make assumptions about human behaviors when designing controls. Much of the research in management control is based on economic models. Using the mathematical formulations of utility functions, these models assume that individuals are rational, self-interested, utility-maximizing agents who experience disutility in work-related efforts. These models also assume that without monitoring and negative sanctions, self-interested individuals will be risk averse and often exhibiting shirking behaviors. Research findings support the notion that incentive is a major motivator in the corporate world (Jensen and Meckling, 1976; Holmstrom, 1979; Fama and Jensen, 1983; Jensen, 1983).

In contrast, modern behavioral or organizational theorists build their work from Maslow's or Herzberg's theory (Maslow, 1943; Herzberg, 1966). Maslow acknowledged that human behavior is subjected to two major needs, i.e. physical/security needs and emotional/psychological needs. For example, Maslow's theory assumes that a need ceases to be a motivator once it is satisfied. As a result, material incentives are no longer motivators once the workers have stable and well-paying job. When that happens, opportunities for developing self-esteem or self-actualization will be a prime motivator for better performance. In summary, underlying the work of both Maslow and Herzberg is the assumption that increased job satisfaction leads to increased performance.

Building upon the work of Maslow and Herzberg, recent organizational theorists (e.g., Hackman and Oldman, 1980; Hackman and Wageman, 1995) suggest that intrinsic motivation, job satisfaction, and work performance are often promoted by including meaningful work and responsibility for work outcomes into the design of work activities. Responsibility often involves decision-making authority and autonomy as far as how the work gets accomplished. Because these features are typically present in JIT organizations, the authors suggest that these firms should possess a structural or design advantage leading to intrinsic motivation and ultimately, performance improvement.

Within the context of controls, Simons (1995a, 1995b) assumes that people want to contribute, to do right, to achieve, and to create. According to Simons, in the absence of leadership or control, however, individuals will become self-interested and work for their own benefit with little regard to organizational goals. In addition, as organizations get bigger, managers cannot count on hiring good people. Instead, it is the control mechanisms that should be in place to promote goal congruence. Underlying Simons' theory is the assumption that despite some structural advantages associated with a new work system, productivity gain may not be realized unless the complimentary control mechanisms are in place. This means organizational failures are often due to organizational blockages. Accordingly, we suggest that to achieve goal congruence in organizations, both extrinsic and intrinsic motivation should be incorporated when designing controls. As such, this paper focuses on the role of performance evaluation systems as a tool for promoting intrinsic and extrinsic motivation whereby leading to productivity gain in a JIT environment. In particular, the performance evaluation systems will comprise of two subsystems, namely, the information system and the reward system.

Information Systems

Performance goals and Attention-directing feedback

In a comprehensive review of the literature on goal setting, Locke and Latham (1990) concluded that goals positively influence the attention, effort, and persistence behaviors of employees. This conclusion is robust across studies that examined self-set, participatively set, or assigned goals, across both laboratory and field settings (Locke et al., 1981; Latham and Lee, 1986; Locke and Latham, 1990). Daniel and Reitsperger (1991) provided empirical evidence that suggests that Japanese automobile and consumer electronic firms focusing on continuous improvement strategies often experience enhancements to their operations through the use of combined goals provision and frequent manufacturing performance feedback. Thus, to assist workers achieve better manufacturing performance, performance goals or targets are often provided via the firm's information system. These targets include customer satisfaction, customer complaints, on-time delivery, defect rate, rework, warranty costs, sales returns and cycle time performance.

From a learning standpoint, providing performance feedback helps employees develop effective task strategies in both complex and novel tasks (Erez 1977; Nadler, 1979; Locke and Latham, 1990, 1991). In fact, Banker et al. (1993, p. 33) indicate that the reporting of manufacturing performance measures to workers is associated with the implementation of JIT, teamwork, and total quality management practices. Thus, in an environment that calls for continuous improvement, it is imperative that the information system should provide performance goals as well as attention-directing feedback to workers.

On the other hand, because of a lower inventory in a JIT production system, workers tend to get task feedback about their own work even in the absence of attention-directing feedback as provided via the firm's information systems. For example, Claxton and Foster (1990) present

anecdotal evidence indicating that process visibility is enhanced when inventories are minimized, while Alles et al. (1997) argue that JIT shortens feedback loops and provides process information in real time to managers. Similarly, Klein (1989) suggests that employees become more self-managing under JIT and statistical process control. These employees often receive immediate and impartial feedback regarding their own performance since they investigate process improvements and monitor quality themselves. Indeed, in a laboratory study, Schultz et al. (1997) supported their hypothesis that JIT increases task feedback. Consequently, this raises the question that whereas providing attention-directing feedback is crucial for employees to develop effective task strategies, this may not be the case in a JIT production system due to the transparency or shorter feedback loop inherent in a JIT production system. Nevertheless, except for Schultz et al. 1997, perhaps, no research studies have examined the impact of a JIT system on perceived task feedback. Accordingly, this study will revisit this issue again.

Sarkar (1997) provides support for expecting strong complementarities between process improvement and information sharing. Results show process improvement in quality is enhanced when information sharing is encouraged in the work place. Thus, we suggest that information systems that provide performance goals and attention-directing feedback to workers will enhance manufacturing performance. Specifically, we argue that although performance goals or attention-directing feedback may be effective independently of JIT implementation, it is the synergy between manufacturing systems (JIT) and information systems (performance goals and attention-directing feedback) that produce higher synergistic performance.

The Reward System

To many researchers, the benefits of tying pay to performance are obvious (see, for example, Jensen and Meckling, 1976; Baker et al., 1988; Wruck and Jensen, 1994). Yet, firms often resist introducing bonus-based compensation plans. One explanation offered by social psychologists or behaviorists is that monetary reward can be counter productive. For example, Deci (1972) argues that money actually lowers employee motivation, reducing the “intrinsic motivation” that an employee receives from the job. Similarly, Deming (1986) criticizes that extrinsic rewards diminish the intrinsic value and motivation of the work. A second group of merit-pay critics argue that although financial incentive schemes improve productivity, they also induce significant adverse side effects which outweigh the limited organizational benefits they offer (Hemner, 1975; Beer et al., 1984). Among the side effects cited are problems associated with imperfect performance measurement.

Baker et al. (1988), however, suggest otherwise. Their careful examination of the criticisms of pay-for-performance systems indicates that problems arise not because that these systems are ineffective, but rather because they are *too* effective. According to Baker et al. (1988, p. 597), “strong pay-for-performance motivates people to do exactly what they are told to do. Large monetary incentives generate unintended and sometimes counterproductive results because it is difficult to adequately specify exactly what people should do and therefore how their performance should be measured.” Consistent with this argument, it appears that in a manufacturing environment that sets goals for continuous improvement in manufacturing processes, the so called side effects of pay-for-performance can be minimized because the appropriate performance matrices often centered around manufacturing performances. This implies that incentive pay rather than fixed pay should work well with JIT manufacturing where

the management also provides performance goals and attention-directing feedback to the workers.

In an observational study of an engine plant, Klein (1987) suggests that JIT could be very stressful – stressful for the slow person and stressful for the fast person. In another survey of organizations implementing JIT systems in France, Gorgeu and Mathieu reported that in all the companies they studied, especially those with a large unskilled labor force, the psychological shock has been very significant. The content of work had changed and blue-collar workers were asked to take on a bigger workload and more responsibility. Very often these changes were met with resistance among foremen who came up through the ranks. Similarly, Schonberger (1982, p. 27) wrote, “In the Toyota Kanban system, for example, each time that workers succeed in correcting the causes of recent irregularity . . . the managers remove still more buffer stock. The workers are never allowed to settle into a comfortable pattern; or rather, the pattern becomes one of continuously perfecting the production process.”

Given that the job content under JIT manufacturing is significantly different from that of a traditional mass production system, we expect to see changes in the incentive system as means to motivate workers in a JIT manufacturing. For example, Alles et al. (1995) suggest that JIT systems often lead to higher worker productivity and efficiency and they also make processes more visible and transparent. Thus, workers should be paid a higher compensation with a smaller piecework component. Furthermore, MacDuffie (1995, p. 201) argues that multiple skills and conceptual knowledge developed by the work force under flexible production are of little use unless workers are motivated to contribute mental as well as physical effort. However, workers will contribute discretionary effort to problem-solving only if they believe that their individual interests are aligned with those of the company, and that the company will make a

reciprocal investment in their well-being. In the absence of an equitable pay system, workers' morale may be low and the promised benefits of flexible manufacturing may not be realized. More recently, Ichniowski et al. (1997) show that workers' performance is substantially higher under incentive pay plans when they are coupled with supportive work practices, which include flexible job assignments, information sharing, and employment security.

It appears that, in a JIT manufacturing, because of a higher stress level as well as a higher expectation of workers' performance, workers will demand a more equitable pay. In view of this, we argue that, in the absence of incentive pay, it is likely that there may be a lack of synergy between JIT and information systems. Conversely, the interactions between manufacturing systems (i.e., JIT) and information systems (i.e., performance goals and more frequent attention-directing feedback) are dependent on the reward system (i.e., incentive vs. fixed pay plans). As a result, the following hypotheses are formulated.

H1a: The favorable interaction effect of JIT and performance goals on manufacturing costs is dependent on the reward system.

H1b: The favorable interaction effect of JIT and performance goals on warranty costs is dependent on the reward system.

H2a: The favorable interaction effect of JIT and attention-directing feedback on manufacturing costs is dependent on the reward system.

H2b: The favorable interaction effect of JIT and attention-directing feedback on warranty costs is dependent on the reward system.

RESEARCH METHODOLOGY

This study investigates the of JIT implementation, the choice of reward and information systems (i.e., performance goals and attention-directing feedback) on manufacturing

performance (as measured by changes in manufacturing costs and warranty costs). The research methodology employed to study the main and interaction effects is summarized below.

Sample Selection

The electronics industry (SIC Code 36) was chosen as the primary industry for the study for the following reasons. The JIT concept works well mainly in repetitive manufacturing such as automobiles, appliances and electronic goods. Balakrishnan et al. (1996) reported that 68 percent of JIT firms (i.e., those that have adopted the JIT concept for a substantial portion of their operations) clustered within the three SIC codes 35, 36 and 38. The sample for the study was drawn from the electronics industry (SIC code 36) since Balakrishnan et al. (1996) indicated that it has the highest percentage of JIT firms. Firms with the SIC code 3624 (i.e., carbon and graphite products) were excluded in the sample selection process because carbon and graphite may not be processed in repetitive manufacturing like most electronic goods.

Letters requesting participation in the research study were sent to the directors of manufacturing of 1,500 randomly selected plants located within the United States with annual sales of ten million dollars and above. A total of 173 responses was received, with nineteen respondents indicating that they were either non-manufacturing or that their manufacturing was done overseas. Thus, they were not appropriate sampling units for the study. A further twenty-five plants indicated that they would not participate in the study. More important, a total of 126 plants agreed to participate in the study and three plants wished to review the questionnaire prior to making a commitment to participate. As a result, a total of 129 questionnaires were mailed out. About 50 percent of the firms replied within four weeks. Six weeks after the initial mailing of the questionnaires, a status report, together with a reminder to complete the questionnaire, was

sent to all 129 plants. In total, 77 useable responses were received, giving a response rate of about 60 percent.

Dependent Variable Measures

Theoretically, firms implementing JIT should experience improvement in product quality, decreased in scrap, rework, lead time, setup time, and ultimately improvement in financial performance such as lower product costs and lower warranty costs. Accordingly, changes in manufacturing costs and warranty costs were used as surrogates for manufacturing performances in the study. Respondents were requested to indicate the changes in the last three years, anchoring on a scale of 1 to 5, where 1="decrease tremendously", 3="no change" and 5="increase tremendously". This is reflected in Appendix A.

Independent Variable Measures

Four independent variables (namely, Just-in-Time, contingent reward system, performance goals, and feedback) were included in the study (see, Appendix A). Where a variable consists of multiple items, an average score across the items represents the score for that variable.

Just-In-Time (JIT)

The JIT scale was adapted from Sim and Killough (1998), which was a modified scale from Snell and Dean (1992). Snell and Dean (1992) developed a 10-item scale anchored on a 7-point Likert scale to measure JIT adoption. Sim and Killough (1998) retained eight of the above items. The first omitted item relates to the extent to which the accounting system reflects costs of manufacturing. This item loaded onto the TQM construct in the Snell and Dean (1992) study and

did not seem to reflect a JIT construct. The second omitted item asked whether the plant was laid out by process or product. Group technology is often part of JIT implementation but not a necessary condition. Perhaps, that is why this item has a low loading score in Snell and Dean (1992). Sim and Killough added one item to their modified JIT scale. This item asked “time spent to achieve a more orderly engineering change by improving the stability of the production schedule.” Cronbach alpha for JIT is 0.63.

The Reward System

The reward system consists of two categories, namely “fixed pay only” or “incentive plan”. Specifically, plants using “fixed pay only” were coded as “0”, while the remaining plants were coded as “1”, resulting in a dichotomous variable.

Performance goals and Attention-Directing Feedback

To enhance manufacturing performance, contemporary information systems set “targets to achieve” as well as providing attention-directing feedback to workers. A total of 11 attributes were chosen as “targets and attention-directing feedback” that were deemed important measures in a manufacturing setting. These attributes, or performance matrix, pertain to customer, delivery, quality, and cycle time performance. The performance matrix was cross referenced with *Practices and Techniques: Managing Quality Improvements* (Institute of Management Accountants 1993), the GAO report, *Management Practices* (GAO 1991), and Lynch and Cross (1991) to make sure that they represent important performance measures recommended in the literature. Using the performance matrix, respondents were asked whether “specific numeric targets” and “performance feedback” were provided to the workers. Following Daniel and Reitsperger (1992), performance goals were anchored on two points, 1=Yes or 0=No; while frequency of feedback information was anchored on a 5-point Likert scale (5= Daily, 1=Never).

The Cronbach alphas for performance goals and attention-directing feedback are 0.69 and 0.70 respectively.

Research Model and Testing Procedures

As discussed earlier, manufacturing performance can be improved with JIT, performance goals (GOAL) and more frequent attention-directing feedback (FEEDBACK). In particular, it is argued that JIT interacts with GOAL and FEEDBACK to affect performance. However, this interaction is dependent on the reward system (COMPENSATION), dichotomized in this study as incentive and fixed pay. It is hypothesized that in the presence of incentive pay, JIT interacts favorably with GOAL and/or FEEDBACK to enhance performance. Conversely, in the presence of fixed (non-incentive) pay, the favorable interaction described above is reduced or eliminated.

Multiple regression with interaction terms is used to test the research hypotheses. The dependent variable (performance) is measured alternatively by changes in manufacturing costs and changes in warranty costs (hence, two regression runs are performed). The independent variables comprise main and interaction effects, with the main effects being JIT, GOAL, FEEDBACK and COMPENSATION. The two-way interaction effects included are JIT*GOAL, JIT*FEEDBACK and JIT*COMPENSATION. Finally, the research hypotheses are tested with the following two three-way interaction effects: JIT*GOAL*COMPENSATION and JIT*FEEDBACK*COMPENSATION.

As per the research hypotheses, the three-way interaction effects are expected to be statistically significant. If they are found to be, the significant three-way interaction effects will be further examined using interaction plots (showing the effect of COMPENSATION [i.e., incentive pay versus fixed pay] on the interaction between JIT and GOAL/FEEDBACK). This

approach is particularly useful when examining the theory of “fit” (Arnold, 1984; Stone and Hollenbeck, 1984; Hartmann and Moers, 1999). It is expected that a higher level of performance should be attained by plants using higher levels of JIT, performance goals or attention-directing feedback in the presence of incentive pay.

It is noted that when interaction effects are included in regression models, it is common to find significant multicollinearity which may confound the results. This problem is handled in the study by centering the variables (Jaccard et al., 1990; Hartmann and Moers, 1999). Finally, to control for the size effect across the sample companies, the variable SIZE is included in the regression models as a control variable. This is measured in terms of annual sales.

RESULTS AND DISCUSSION

This section discusses the descriptive statistics, results related to the research hypotheses and the findings.

Descriptive Statistics

Table 1, Panel A, summarizes the respondents’ job titles. As shown, most respondents were closely associated with manufacturing operations. Information on annual sales is presented in Table 1, Panel B. About 50 percent of the sample had annual sales of between 10 to 50 million dollars.

Table 2 shows the means, standard deviations and zero-order correlations. The correlation matrix suggests that manufacturing plants that made greater use of JIT also made greater use of the incentive-pay reward system, more frequently set goals on operational performance, and more frequently provided attention-directing feedback to their workers. Further, greater use of JIT is associated with lower warranty costs but its association with lower

manufacturing costs is not statistically significant. Also, there is little or no association between incentive pay and better manufacturing performance.

Insert Tables 1 and 2 about Here

Multiple Regression Results

Table 3 summarizes the results of the regression analyses. Given the research hypotheses, emphasis is placed on the three-way interaction terms. With the change in manufacturing costs as the dependent variable (see Panel A), the regression model is significant with a p -value of 0.01. The R-square is 28.30%. Also, at a significance level of 0.05, both the three-way interaction effects (JIT*GOAL*COMPENSATION and JIT*FEEDBACK*COMPENSATION) are statistically significant, with p -values of 0.03 and 0.04, respectively.

Insert Table 3 about Here

To further analyze the significant interaction effects, the interaction plots are given in Figures 1 and 2. In drawing the interaction plots, the means of GOALS and FEEDBACK are used as cutoff points to separate the sample into high/low goal-setting and high/low feedback, respectively. As shown in Panel A, increasing levels of JIT interact with higher levels of performance goals to improve manufacturing costs only in the presence of incentive pay. With fixed pay, however, the JIT*GOAL interaction has an adverse effect on manufacturing costs.

Notice that the two lines are almost parallel, suggesting, perhaps, there is no 2-way interaction. Also, the nature of the graph for ‘fixed-pay’ group suggests possible main effects for performance goals and JIT. Consequently, further regression analysis on ‘fixed pay’ group was tested for possible main effects and 2-way interaction effects. Regression analysis indicated that there is no 2-way interactions (JIT*GOAL, JIT*FEEDBACK), however, GOAL has a positive effect on performance (with p -value of 0.0001) while JIT has a marginal negative effect on performance (with p -value of 0.06). Also note that the p -values shown in the figure indicate statistical differences in the high/low groups.

Insert Figures 1 and 2 about Here

Although not as obvious as in Figure 1 - Panel A, Figure 2 shows that generally, the presence of incentive pay leads to a positive JIT*FEEDBACK interaction. Notice that the p -values for the ‘fixed pay’ group are not statistically significance.¹ To conclude, results (Table 3 – Panel A, Figure 1 – Panel A, and Figure 2) support the research hypotheses H1a and H2a.

Table 3, Panel B, presents the regression analysis results with the change in warranty costs as the dependent variable. The regression model is significant with a p -value of 0.03; the R-square is 24.82%. As mentioned earlier, only the three-way interaction terms are relevant to testing the research hypotheses. As shown, the JIT*GOAL*COMPENSATION interaction is

¹ This result is consistent with our discussion in the prior paragraph, i.e., there is no interaction effects on manufacturing costs for the ‘fixed pay’ group.

statistically significant at a 0.05 significance level (p -value = 0.03). To further analyze the significant three-way interaction effect, the interaction plot is given in Figure 1 – Panel B.

As shown, increasing levels of JIT and performance goals interact positively to give a favorable effect on warranty costs. However, this favorable JIT*GOAL interaction effect is more pronounced in the presence of incentive pay as compared to the case of fixed pay. These results (Table 3 Panel B and Figure 1 – Panel B) support the research hypothesis H1b. At a 0.05 significance level, there is insufficient statistical evidence to support research hypothesis H2b.

Finally, it can be noted from the low variance inflation factors in Table 3 (VIF < 5) that no significant multicollinearity problems are detected in the regression analyses.

Interaction Effects of JIT, Performance Goals, and the Reward System (H1a and H1b)

Hypothesis 1 predicts that the favorable interaction effect of JIT and performance goals on manufacturing performance (i.e., changes in manufacturing costs or warranty costs) is dependent on the reward system. This hypothesis is supported with results stronger for change in manufacturing costs (H1a). Findings show that JIT interacts with performance goals to produce lower manufacturing costs *only* when incentive pay is used. For plants using fixed pay, however, manufacturing cost is a decreasing function of performance goals but an increasing function (marginal) of JIT. Although hypothesis H1b is also supported, i.e., warranty cost is a decreasing function of JIT, performance goals, and the reward system; synergy also exists between higher level of performance goals and JIT for plants which used fixed pay, but to lesser extent.

It appears that JIT has a marginal negative effect on change in manufacturing cost for firms which use fixed pay, while this adverse effect was not observed for change in warranty costs. This apparent inconsistency can be explained by the structural differences between

manufacturing and warranty costs. Improvement in warranty costs implies either the quality or the reliability of the products has improved. Theoretically, it is possible to improve product quality by incurring less, same, or more resources. For example, manufacturing companies can increase spending in their conformance quality costs (e.g., prevention or appraisal costs) in order to achieve lower nonconforming costs (e.g., lower warranty costs). In contrast, improvement in manufacturing cost is often associated with improved efficiency, i.e., using less resources for the same output. In the absence of extrinsic motivation and coupled with a high level of expectation or stress associated with JIT practices (see the discussion on p. 10), it is likely that workers may not stretch themselves only to maximize firms' returns. Alternatively, the observed results can be explained by possible retaliation from workers when they view the performance evaluation system as inequitable. On the other hand, if lower warranty costs is associated with increased spending in conformance costs, then it may be less likely for workers to retaliate when fixed pay is used. When this happens, the favorable interaction between performance goals and JIT is less dependent on incentive type for warranty costs -- this may be the case of Figure 1- Panel B.

Interaction Effects of JIT, Attention-directing feedback, and the Reward System (H2a and H2b)

Hypothesis 2 predicts that the favorable interaction effect of JIT and attention-directing feedback on manufacturing performance (i.e., changes in manufacturing costs or warranty costs) is dependent on incentive type. H2a is weakly supported while H2b is not supported. Figure 2 shows that manufacturing cost is a decreasing function (marginally) of JIT and attention-directing feedback for firms using incentive pay while there is no synergy between attention-directing feedback and JIT for firms using fixed pay. These findings suggest that performance gain (i.e., reduction in manufacturing cost) is conditional on the use of incentive pay. Also notice

in Figure 2, for firms which use incentive pay, the amount of feedback does not seem to have an impact on manufacturing cost. Manufacturing costs, however, reduce at an increasing level of JIT. Finally, notice that the lowest manufacturing costs are associated with firms using high JIT but low attention-directing feedback

The weaker results for hypothesis 2 may be attributed to the nature of JIT manufacturing as previously discussed. As the level of inventory decreases, manufacturing processes become more transparent. It is plausible that JIT shorten the feedback loops while workers often receive immediate feedback regarding their own performance since they investigate process improvements and monitor quality themselves. Consequently, the frequency of attention-directing feedback may not be as critical in a JIT environment. This finding, however, is consistent with anecdotal evidence that JIT increases task feedback.

Conclusion

There has been an increasing amount of research in the area of JIT manufacturing. However, few studies have attempted to directly link factors which affect workers motivation to manufacturing performance. Sarkar (1997) suggests that there is still confusion and significant cross sectional variation in beliefs about the role of workers in modern manufacturing practices. Building on this, findings from this study provide some evidence that suggests that if proper control procedures are not in place, effort to implement JIT may be futile.

Despite the structural advantage and the associated intrinsic motivation embedded in a JIT production system, by itself JIT does not lead to performance gains. Similarly, findings show that incentive pay or extrinsic motivation per se is not associated with better manufacturing performance. Instead, it is the match between JIT and the performance evaluation systems (i.e.,

the information and reward systems) that produces higher manufacturing performance. In particular, it is found that a favorable interaction effect of JIT and information systems on manufacturing performance is often dependent on the reward system. Although findings are somewhat mixed, they provide some support for normative theory that states that control systems should be designed to encourage workers' behavior, which will increase the probability of meeting the objectives and goals of organizations.

The findings in this study should be interpreted in the light of two potential limitations. The first limitation relates to the small sample size. Because of the small sample size, some sensitivity tests were conducted. First, the distribution of the sample by geographic region (see Appendix A, for the seven geographic regions used in the study) to that of a random sample of 3,000 electronic plants were compared.² The chi-square test shows a p -value of 0.99, indicating no significant difference. Next, the 4-digit SIC code was used as a basis for comparison. *Manufacturing USA—Industry Analysis, Statistics, and Leading Companies* (1992) shows that the leading companies were clustered within five industries (i.e., SIC codes 3621, 3661, 3663, 3674 and 3679). In contrast, the sample in the study clustered within six industries, five of which are the same industries as those reported in *Manufacturing USA* (the addition being SIC code 3651). However, the implications of non-response bias cannot be totally ruled out. For example, the average sample plant may be smaller than an average plant in the electronics industry even though an annual sales of \$10 million and above was used as a cutoff point. Unfortunately, information on average sales at the plant level was not available from any published sources to permit an assessment of any such bias. The second limitation of the study is

² The population consists of slightly over 5000 plants with annual sales of \$10 million and above.

the reliance on self-report measures. Secondary sources were not available to verify the reported data.

The findings of this study, while providing insight into the interaction effect of JIT and control systems on manufacturing performance, leave many unanswered questions that may be pursued by future research. For example, it will be interesting to see whether it is the level of stress inherent in the JIT manufacturing that has produced the adverse effect on manufacturing costs when a high level of performance goals is used in conjunction with fixed pay. In addition, future studies can examine the change in conformance costs relative to the change in warranty costs when examine performance improvement in a JIT environment. Finally, additional features of incentives can be investigated, including tournament vs. cooperative, monetary vs. non-monetary, and pay vs. promotion.

APPENDIX A QUESTIONNAIRE

I. MANUFACTURING PERFORMANCE

In this section, we are interested to know the extent to which the following performance attributes have changed during the past 3 years using the scale of 1-5 listed below: (1=Decrease Tremendously, 3=No Change, 5=Increase Tremendously)

- i. Manufacturing Cost
- ii. Warranty Cost

II. JUST IN TIME

(Anchored by 1=Not at All or Very Little, 4=To Some Extent, and 7=Completely or A Great Deal)

1. Are products pulled through the plant by the final assembly schedule/master production schedule?
2. How much attention is devoted to minimizing set up time?
3. How closely/consistent are predetermined preventive maintenance plans adhered to?
4. How much time is spent in achieving a more orderly engineering change by improving the stability of the production schedule?

How much has each of the following changed in the past three years?
(Anchored by 1=large Decrease, 4=Same, and 7=Large Increase)

- *5. Number of your suppliers
- 6. Frequency of the deliveries
- *7. Length of product runs
- *8. Amount of buffer stock
- *9. Number of total parts in Bill of Material

* Reverse Coding

III. ATTENTION-DIRECTING FEEDBACK

In this section, we are interested in the availability and frequency of performance feedback provided to the shop floor personnel. Please indicate the frequency of feedback by circling the appropriate number from 1 to 5.

1=NEVER 2=OCCASIONALLY 3=MONTHLY 4=WEEKLY 5=DAILY

CUSTOMER PERCEPTION

- Customer perceived quality
- Customer compliant

DELIVERY

- On-time delivery

QUALITY

- Cost of scrap
- Rework
- Defect
- Warranty cost
- Sales return

CYCLE TIME

- Product development time
- manufacturing lead time
- Work station setup time

IV. THE REWARD SYSTEM

1. How are plant workers currently being compensated? (please circle only one).
 - a. Strictly individual fixed pay only
 - b. Individual fixed pay + non-monetary reward
 - c. Individual fixed pay + individual-based monetary incentive
 - d. Individual fixed pay + group-based monetary incentive

V. PERFORMANCE GOALS

Does your firm set specific numeric targets for the following performance measures? (Anchoring on “Yes” or “No”)

CUSTOMER PERCEPTION

- Customer perceived quality
- Customer compliants

DELIVERY

- On-time delivery

QUALITY

- Cost of scrap
- Rework
- Defect
- Warranty cost
- Sales return

CYCLE TIME

- Product development time
- manufacturing lead time
- Work station setup time

VI. BACKGROUND INFORMATION

A. Plant Size

i). The average annual sales is about _____
(If a specific sales level is not available, please check (✓) one of the following)

- | | |
|-------------------------------------|-------------------------------------|
| _____ Below \$10 Million | _____ \$201 Million - \$500 Million |
| _____ \$10 Million - \$50 Million | _____ \$501 Million - \$1 Billion |
| _____ \$51 Million - \$100 Million | _____ \$1 Billion - \$2 Billion |
| _____ \$101 Million - \$200 Million | _____ Above \$2 Billion |

B. Geographic Location

- _____ New England Region (Connecticut, Maine, Massachussets, New Hampshire, Rhode Island, Vermont)

- _____ Middle Atlantic States (New Jersey, New York, Pennsylvania)

- _____ Southern States (Alabama, Arkansas, Delaware, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, West Virginia)

- _____ Midwestern States (Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin)

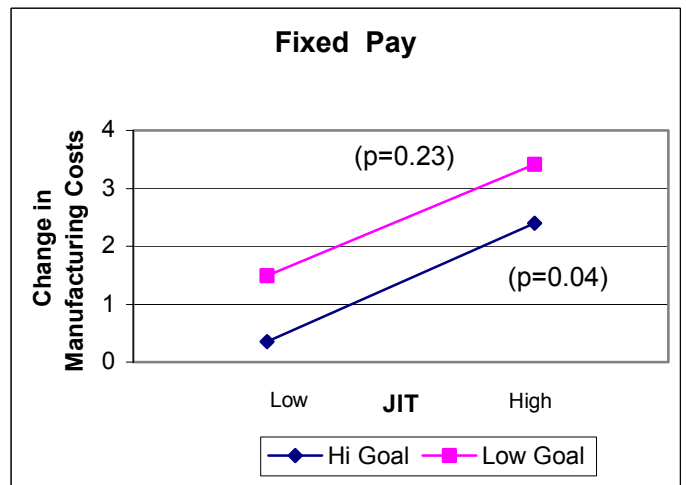
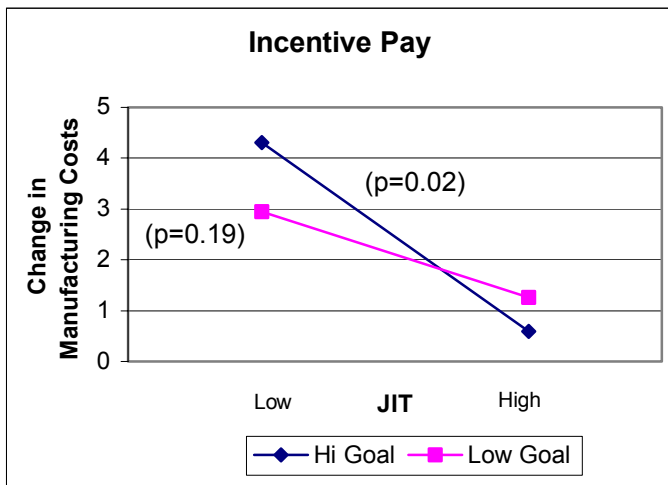
- _____ Rocky Mountain States (Colorado, Idaho, Montana, Nevada, Utah, Wyoming)

- _____ Southwestern States (Arizona, New Mexico, Oklahoma, Texas)

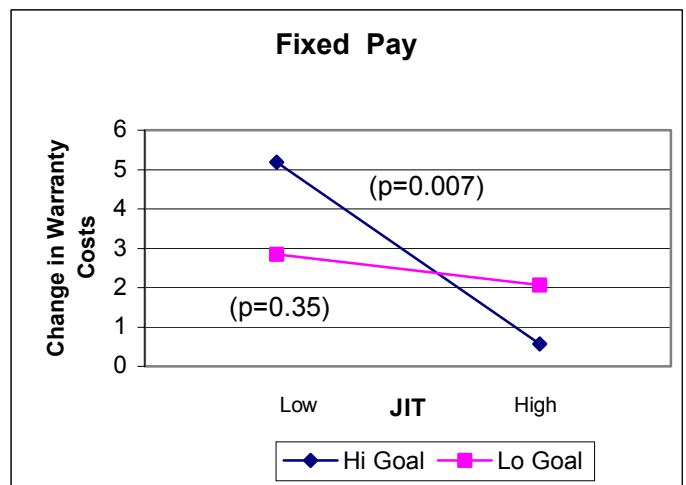
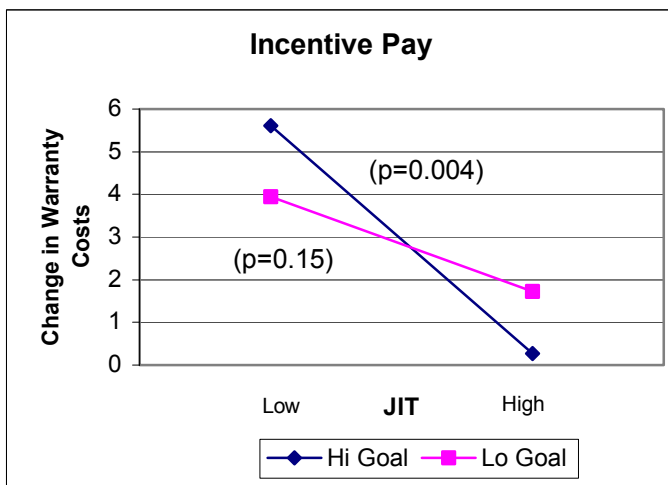
- _____ Pacific Coast States (California, Oregon, Washington)

Figure 1:Three – Way Interaction

Panel A - Changes in Manufacturing Costs
By JIT, Goals, and Compensation Type



Panel B - Changes in Warranty Costs
By JIT, Goals, and Compensation Type



Figures 1 and 2 present least square means for the estimated OLS models with *performance* as the dependent variable. $Perf = f(JIT)$, holding compensation type (a dichotomous variable), and GOAL (FEEDBACK) constant. The median is used to split the sample into high goals (high feedback) and low goals (low feedback). *Perf* scores at JIT=1 (low) and JIT=7 (high) were generated. A more conservative approach of further dividing plants into low and high JIT does not work here due to a small sample size. For example, there are only 36 plants that use fixed pay plan, further blocking these plants into four subgroups has resulted in 5 plants per group in some situations.

Figure 2: Three - Way Interaction
 Changes in Manufacturing Costs
 by
 JIT, Attention-directing feedback, and Compensation Type

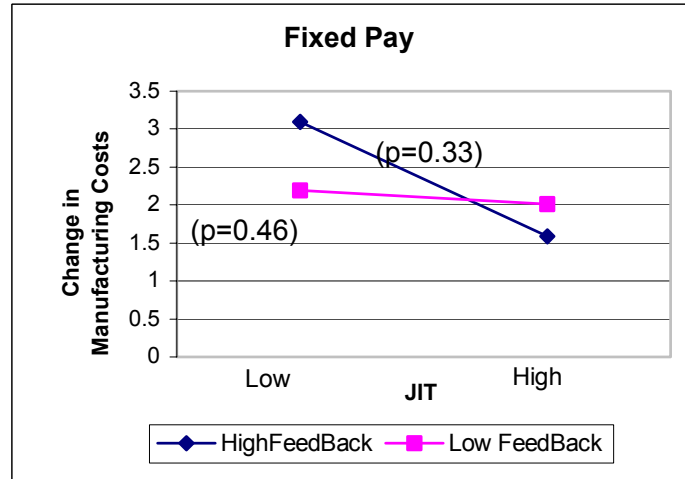
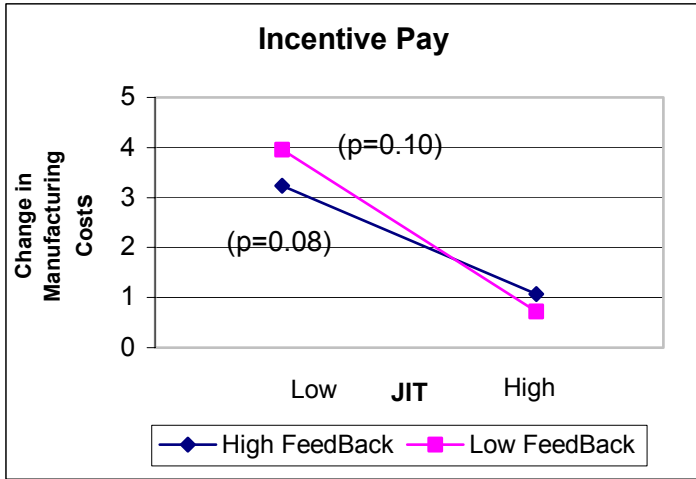


Table 1 – Descriptive Profile of Respondents and Companies

Panel A: Job Title of Respondents

Job Title Used by Respondents	Number of Respondents
Plant Manager, Manufacturing Manager or Operations Manager.	21
VP of Operations, VP of Engineering, VP of Manufacturing or VP of Quality	22
Director of Operations, Director of Manufacturing or Director of Manufacturing and Engineering.	12
CEO, President and CEO, Executive VP or President	5
Miscellaneous Titles such as Materials Manager, Test Manager, Sourcing and Fabrication Manager, Product Integrity Manager and Others.	11
No Information on Job Title	6
Total Respondents	77

Panel B: Annual Sales of the Sample

Annual Sales	Number of Plants
Below \$10 Million	5
\$10 Million - \$50 Million	41
\$51 Million - \$100 Million	14
\$101 Million - \$200 Million	11
\$201 Million - \$500 Million	4
\$501 Million - \$1 Billion	1

Total:	76 ^a
	====

^a One respondent did not provide annual sales information.

Table 2 - Zero Order Correlation

Variable	Mean	Std. Dev.	Cronbach Alpha	1	2	3	4	5
1. JIT	4.69	0.65	0.63					
2. Compensation type	0.55	0.50	N/A	0.30**				
3. Goal-setting	0.65	0.26	0.69	0.44***	0.09			
4. Feedback	2.95	0.62	0.79	0.34**	0.20#	0.45***		
5. Change in manufacturing costs	2.03	0.89	N/A	-0.14	-0.09	-0.23*	-0.06	
6. Change in warranty costs	2.22	0.76	N/A	-0.38***	-0.03	0.22#	-0.09	0.19#

Note: 0.18 - 0.22 (p = 0.10)#
 0.23 - 0.28 (p = 0.05)*
 > 0.28 (p = 0.01)**
 >0.38 (p= 0.001)***

Table 3 - Multiple Regression Results of Manufacturing Performance on JIT, Information and Reward Systems

Panel A: Change in Manufacturing Costs

Variable	Coefficient	t-statistic	p-value	VIF
Intercept	2.03	8.93	0.00***	0.00
Size	-0.02	-0.32	0.37	1.14
JIT	-0.05	-0.29	0.39	1.69
Compensation type	-0.01	-0.08	0.47	1.42
Goal-setting	-1.24	-2.90	0.00* *	1.56
Feedback	-0.06	-0.33	0.37	1.46
JIT*Compensation-type	-0.14	-0.85	0.20	1.30
JIT*Goal-setting	0.18	0.23	0.41	1.43
JIT*Feedback	0.19	0.62	0.27	1.74
JIT*Goal-setting*Compensation-type	-1.45	-1.85	0.03*	1.85
JIT*Feedback*Compensation-type	0.54	1.80	0.04*	1.82
Model F-value = 2.566**				
R-square = 0.2830				

Panel B: Change in Warranty Costs

Variable	Coefficient	t-statistic	p-value	VIF
Intercept	2.30	10.30	0.00***	0.00
Size	0.03	0.37	0.36	1.14
JIT	-0.62	-3.29	0.00* **	1.69
Compensation type	0.12	1.11	0.14	1.42
Goal-setting	-0.22	-0.51	0.31	1.56
Feedback	0.06	0.32	0.37	1.46
JIT*Compensation-type	0.06	0.33	0.37	1.30
JIT*Goal-setting	-0.39	-0.44	0.33	1.43
JIT*Feedback	-0.38	-1.12	0.13	1.74
JIT*Goal-setting*Compensation-type	-1.66	-1.86	0.03*	1.85
JIT*Feedback*Compensation-type	0.52	1.54	0.06	1.82
Model F-value = 2.179 *				
R-square = 0.2482				

*** $p < 0.001$
 ** $p < 0.01$
 * $p < 0.05$

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