# An Empirical Examination Of Management Control Systems In Just-In-Time Manufacturing

Khim Ling Sim, (E-mail: ksim@wnec.edu), Western New England College
Hian Chye Koh, (E-mail: ahckoh@ntu.edu.sg), Nanyang Technology University, Singapore

**Abstract**

*Proponents of JIT techniques often argue that Japanese manufacturing techniques are among the best in the world. On the other hand, critiques have called the JIT manufacturing techniques "management by stress" and that they are often associated with high work intensity, stress, and fatigue. Prompted by some recent findings, organizational theorists began to question whether these new work practices will have a sustaining effect on performance. Consistent with the social technical systems theory, this study suggests that unless complimentary changes also occur in other related systems within an organization, the perceived productivity gain of a new work system may not be realized. Findings provide some support for the hypotheses tested. For example, results show 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, results show JIT interacts with performance goals to produce lower manufacturing costs only when incentive pay is used. For plants using fixed pay, however, manufacturing costs are a decreasing function of performance goals but a marginal increasing function of JIT.*

## 1.0 Introduction

Recent research findings have cast some doubt over the success of new work practices, also known as alternate work practices (see Godard, 2001; Osterman, 2000). These new work practices often include some combination of work reorganization, such as autonomous work team, increased job training, job rotation, and multi-skilling. It is claimed that they transform work places into high performance models (see, for example, Ichniowski et al., 1996; Kochan and Osterman, 1994; Pfeffer, 1998)). Using a sample of 508 employed Canadians, Godard (2001) reported that moderate levels of these new work practices were associated with increased empowerment, task involvement, and ultimately job satisfaction. At higher levels of adoption, however, these associations declined in magnitude and even became negative. Moreover, some of the new work practices, such as JIT and re-engineering programs, were associated with more stressful work.

In a separate study, Osterman (2000) reported that although "high performance work organizations" continue to diffuse at a rapid rate at the later part of the 1990's, they were associated with increased layoff rates and with no compensation gains. Given these findings, organizational theorists began to question whether these new work practices will have a sustained performance enhancement effect. On the other hand, NUMMI (New United Motors Manufacturing, Inc), the General Motors–Toyota joint venture in Fremont, California, has often being cited as one of the leanest approaches to build automobiles. Productivity, since its inception in 1984, remains one which few other assembly plants in the North American can match (Adler & Goldoftas, 1999; Black, 1999). Because of these mixed findings, there is a growing interest in understanding factors which inhibit successful implementation of new work practices. In particular, interests in how to blend the Japanese thinking and philosophies into the American work experience remain high.

*Readers with comments or questions are encouraged to contact the authors via email.*

Proponents of JIT techniques often argue that the Japanese manufacturing management techniques are among the best in the world (see, for example, Schongerger, 1982; Womack et al., 1992). On the other hand, critiques have called the JIT manufacturing techniques "management by stress". Under JIT, the best practice remains an ever shifting target. Often, these moving targets present some form of stress to workers and incidents of cumulative trauma disorders in these work places have intensified greatly (Fairris and Brenner, 2001). Critics have often argued that Japanese management techniques are associated with high work intensity, stress, and fatique and thus they outweigh the benefits. (Fucini and Fucini, 1990; Babson, 1993; Lewchuck et al., 1997; Rienhart et al., 1997; Landsbergis et al., 1999). For example, a survey of workers at the Mazda plant in Flat Rock, Michigan, revealed that three-quarters of the surveyed work force felt that their work pace was so intense that they would be either injured or worn out before they reached retirement (Babson, 1993).

Research findings on JIT implementation are, in most part mixed. Inman and Mehra (1993) found a significant relationship between financial success and JIT implementation while Balakrishnan et al. (1996) found somewhat weak results with respect to differences in return on assets between JIT and non-JIT firms. More recently, Alles et al. (2000) showed that lowering inventory and increaseing the skill levels of workers are related to improved process reliability, product quality, and cost. On the other hand, Dean and Snell (1996) reported no significant relationship between JIT implementation and manufacturing performance. Similarly, Sakakibara et al. (1997) found no significant relationship between the use of JIT practices and manufacturing performance. These mixed findings, however, can be explained by some extant literature. For example, social technical systems theory states that changes in a 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 the 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; Wruck and Jensen, 1994; Milgrom and Roberts, 1990, 1995). Accordingly, the aim of the paper is to examine the facotrs which will compliment JIT or the Japanese manufacturing techniques, thereby leading to better manufacturing performance (as measured in terms of reduction in manufacturing costs).

## 2.0 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 the identification of hypotheses to be tested.

### 2.1 JIT Manufacturing Techniques

JIT programs rely on persistence in pursuing continuous incremental improvement in manufacturing operations. A vital part of every Just-in-Time manufacturing is the reduction of setup time, lot sizes, and inventories. Smaller lot sizes lead to shorter manufacturing cycle time 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 (Fine, 1993; Groenevelt, 1993).

Continuous improvement in the manufacturing processes, a key feature of JIT, should lead to increased productivity and hence lower manufacturing costs. Likewise, job rotation removes monotony in a repetitive manufacturing environment. Moreover, 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. Finally, supplier-relation management further enhanced the JIT philosophy. For example, NUMMI, following the Toyota philosophy, usually keeps one or two suppliers per part, challenges their suppliers to make product and process improvement, and works with them when problems arise. As mentioned earlier, successful implementation of advanced manufacturing systems such as JIT requires changes in management control systems. Accordingly, the next section addresses issues related to management control systems.

### 2.2 Management Control Systems

Management control systems are sets of tools used to motivate employee'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. Within the context of controls, Simons (1995a, 1995b) assumes that people want to contribute, do right, achieve, and create. However, in the absence of leadership or control, individuals will become self-interested and work for their own benefit with little regard to organizational goals. Underlying Simons' theory is the assumption that despite some structural advantages associated with the JIT system, productivity gain may not be realized unless complimentary control mechanisms are in place. Since JIT techniques are closely in line with Japanese thinking and philosophy, modifications should be made in American management control systems such that the benefit of the JIT techniques can be realized. As such, this paper focuses on the role of performance evaluation systems as a tool for promoting extrinsic motivation whereby leading to productivity gain in a JIT environment. In particular, the performance evaluation system will comprise of two subsystems, namely, the information system and the reward system.

### 2.3 Information Systems

#### 2.3.1 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 of employees. This conclusion is robust across studies that examined self-set, participatively set, or assigned goals, across both laboratory and field settings. In addition, from a learning standpoint, providing performance feedback helps employees develop effective task strategies in both complex and novel tasks (Locke et al., 1981; Locke and Latham, 1990; Latham and Locke, 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. For example, Claxton and Foster (1990) present anecdotal evidence indicating that process visibility is enhanced when inventories are minimized. Indeed, in a laboratory study, Schultz et al. (1997) supported their hypothesis that JIT increases task feedback. Consequently, this raises the question as to whether providing attention-directing feedback is crucial for employees to develop effective task strategies in a JIT production system because of the transparency or shorter feedback loop inherent in a JIT production system. Accordingly, this study will revisit this issue again.

Sarkar (1997) provides support for expecting strong complementarities between process improvement and information sharing. Results show that process improvement in quality is enhanced when information sharing is encouraged in the work place. Thus, information systems that provide performance goals and attention-directing feedback to workers will enhance manufacturing performance. Specifically, 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.

#### 2.3.2 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, Deming (1986) states that extrinsic rewards diminish the intrinsic value and motivation of the work. Other 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).

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 are often centered around manufacturing performances.

In an observational study of an engine plant, Klein (1987) suggests that JIT can be very stressful – stressful for the slow person and stressful for the fast person. 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." Because of a higher stress level as well as a higher expectation of workers' commitment and their performance, it is likely that workers will demand a more equitable pay. In view of this, 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 JIT systems 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.

*H1: The favorable interaction effect of JIT and performance goals on manufacturing costs is dependent on the reward system.*

*H2: The favorable interaction effect of JIT and attention-directing feedback on manufacturing costs is dependent on the reward system.*

### 3.0 Research Methodology

This study investigates JIT implementation and 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). The research methodology employed to study the main and interaction effects is summarized below.

### 3.1 Sample Selection

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. Thus, the sample for the study was drawn from the electronics industry (SIC code 36). 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.

### 3.2 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.

#### 3.2.1 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 whether "time spent to achieve a more orderly engineering change by improving the stability of the production schedule." Cronbach alpha for the JIT measure is 0.63.

### 3.2.2 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.

### 3.2.3 Performance Goals and Attention-Directing Feedback

To enhance manufacturing performance, contemporary information systems set goals or "targets to achieve" as well as provide attention-directing feedback to workers. A total of 11 attributes was 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) to make sure that they represent important performance measures recommended in the literature. Using the performance matrix, respondents were asked whether "specific numeric targets" or goals and "performance feedback" were provided to the workers. 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.

## 3.3 Dependent Variable Measure

Respondents were asked to indicate the change in manufacturing costs in the last three years, anchoring on a scale of 1 to 5, where 1="decrease tremendously", 3="no change" and 5="increase tremendously".[1]

## 3.4 Control Variables

To control for the size effect across the sample companies, the variable SIZE is included in the regression model as a control variable. This is measured in terms of annual sales. As discussed earlier, in a JIT setting, continuous improvement of the production processes lies with the workers, i.e., instead of leaving the job design to methods engineering department, workers are actively involved in the process of job design and redesign through the "standardized work" process. Accordingly, the extent to which workers was empowered should affect successful implementation of JIT programs. Thus, workers' empowerment is included in the model. The measure for empowerment is adapted from Sim and Carey (2002) and operationalized using four items on a 7-point Likert scale of 1 = "Strongly Disagree" to 7 = "Strongly Agree". Using principal component analysis, all four items loaded onto the same factor, with 56% of variance explained and a Cronbach alpha of 0.73. Appendix A provides detailed information on the empowerment scale.

## 3.5 Research Model and Testing Procedures

[1] Multiple performance measures (dependent variables) were collected for the purpose of a large scale study.

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 by changes in manufacturing costs. The independent variables form the 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 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).

## 4.0 Results And Discussion

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

### 4.1 Descriptive Statistics

About 50 percent of the sample had annual sales of between 10 to 50 million dollars. There are 16 plants with annual sales of more than $100 Million. Table 1 summarizes the respondents' job titles. As shown, most respondents are key personnel who are closely associated with manufacturing operations. 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 as well as give more autonomy to them. There is, however, no association between incentive pay and improvement in manufacturing costs.

**Table 1 – Job Title of Respondents**

| Job Title Used by Respondents | 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 Engineering. | 12 |
| CEO, President and CEO, Executive VP or President | 5 |
| Miscellaneous Titles such as Materials Manager, Test Manager, or Product Integrity Manager. | 11 |
| No Information on Job Title | 6 |
| Total Respondents | 77 |

**Table 2 - Zero Order Correlation**

| Variable | Mean | Std. Dev. | Cronbach Alpha | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|---|---|
| JIT | 4.69 | 0.65 | 0.63 | | | | | | | |
| Size | 2.63 | 1.13 | N/A | 0.14 | | | | | | |
| Empowerment | 3.40 | 1.25 | 0.73 | 0.21# | -.11 | | | | | |
| Compensation type | 0.55 | 0.50 | N/A | 0.30** | -.02 | 0.26* | | | | |
| Goal-setting | 0.65 | 0.26 | 0.69 | 0.44*** | 0.09 | 0.22# | 0.09 | | | |
| Feedback | 2.95 | 0.62 | 0.79 | 0.34** | 0.19# | .034** | 0.20# | 0.45*** | | |
| Change in manufacturing costs | 2.03 | 0.89 | N/A | -0.14 | -0.04 | -0.19# | -0.09 | -0.23* | -0.06 | |
| Improvement in quality costs | 2.22 | 0.76 | N/A | 0.21# | 0.08 | 0.11 | 0.26* | 0.29** | 0.11 | -0.30*** |

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 summarizes the results of the regression analysis. Given the research hypotheses, emphasis is placed on the three-way interaction terms. The regression model is significant with a *p*-value of 0.01. The Adjusted R-square is 16.36%. 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 0.05, respectively. 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 analysis.

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

| Variable | Coefficientt- | statistic | p-value | VIF |
|---|---|---|---|---|
| Intercept | 2.30 | 5.31 | 0.00*** | 0.00 |
| Size | 0.04 | -0.48 | 0.32 | 1.19 |
| Empowerment | 0.06 | -0.68 | 0.25 | 1.27 |
| JIT | 0.01 | -0.06 | 0.48 | 1.72 |
| Compensation type | 0.01 | 0.12 | 0.45 | 1.44 |
| Goal-setting | -1.22 | -2.83 | 0.00** | 1.57 |
| Feedback | -0.06 | -0.32 | 0.37 | 1.58 |
| JIT*Compensation-type | -0.10 | -0.63 | 0.26 | 1.34 |
| JIT*Goal-setting | 0.16 | 0.50 | 0.31 | 1.89 |
| JIT*Feedback | 0.14 | 0.18 | 0.43 | 1.41 |
| JIT*Goal-setting*Compensation-type | -1.50 | -1.90 | 0.03* | 1.84 |
| JIT*Feedback*Compensation-type | 0.541 | 1.66 | 0.05* | 1.89 |

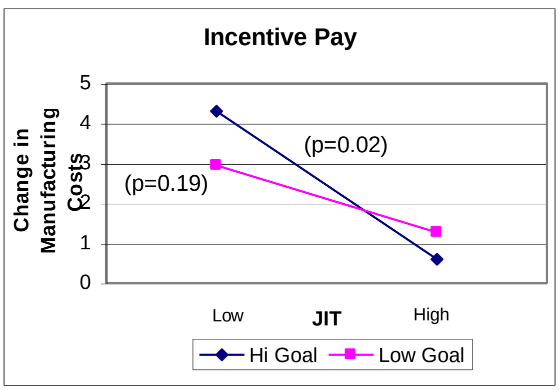
Model F-value = 2.32**
Adj. R-square = 0.1636

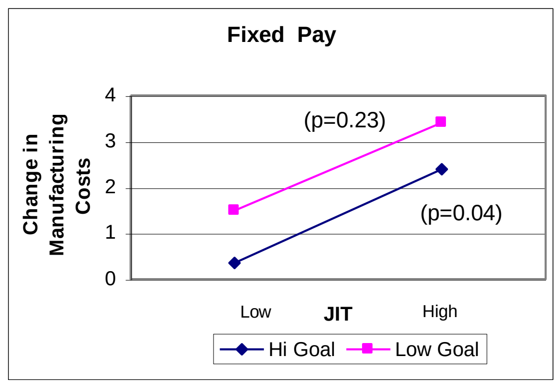
*** $p$ <0.001
** $p$ < 0.01
* $p$ < 0.05

To further analyze the significant interaction effects, the interaction plots are given in Figure 1, Panels A and B. In drawing the interaction plots, the medians 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. Also, the nature of the graph for the 'fixed-pay' group suggests possible main effects for performance goals and JIT. Consequently, further regression analysis on the 'fixed pay' group was tested for possible main effects and 2-way interaction effects. Regression analysis results indicate that there is no significant 2-way interaction (JIT*GOAL, JIT*FEEDBACK) within the fixed pay group; 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). Note that the *p*-values shown in the figure indicate statistical differences in the high/low groups. These results provided support for hypothesis 1 and suggest that the favorable interaction effect of JIT and performance goals on manufacturing costs is dependent on the reward system. One plausible explanation for the negative effect of JIT on manufacturing costs for the fixed pay firms can be due to "mismatches", as explained in the prior sections.

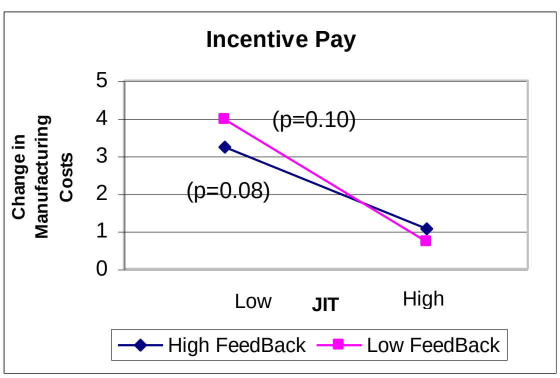
Figure 1, Panel B, shows that manufacturing costs are an increasing function of JIT and attention-directing feedback for firms using incentive pay while there is no synergy between attention-directing feedback and JIT for firms using fixed pay. These findings suggest that performance gain (i.e., reduction in manufacturing costs) is conditional on the use of incentive pay. However, the highest improvement in quality costs (i.e., lowest manufacturing costs) is associated with firms using high JIT but *low* attention-directing feedback. Thus, hypothesis 2 is marginally supported.

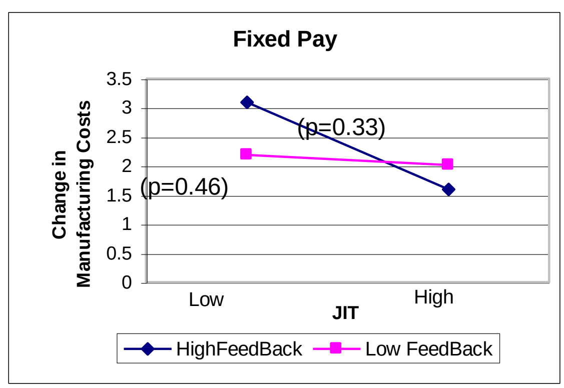
**Figure 1: Three – Way Interaction**
**Panel A - Changes in Manufacturing Costs, By JIT, Goals, and Compensation Type**




**Panel B - Changes in Manufacturing Costs, by JIT, Feedback, and Compensation Type**




Note: Change in manufacturing cost anchoring on a scale of 1 to 5, where 1="decrease tremendously", 3="no change" and 5="increase tremendously".

The weaker result for hypothesis 2 may be attributed to the nature of JIT manufacturing as previously discussed. That is 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. For example, Alles et al. (2000) suggest that lower inventories provide context-specific feedback about production problems thus improve workers' ability to identify and isolate the underlying causes whereby leading to improved quality performance. Also, this finding is consistent with the finding that JIT increases task feedback (Schultz et al., 1997).

**5.0 Conclusion**

At a time when organizational theorists were questioning the sustaining effects of new work practices, NUMMI's performance continue to surpass its peers. Absenteeism at NUMMI still averages about 4 percent as compared to the national average of 10 percent. Per-vehicle build time ranks among the most efficient in the auto industry in North America. The plant's problem-solving circles continue to generate ideas for improvement. In 1998, the teams generated more than 27,000 suggestions, an average of 6 suggestions per team. Overall, 88 percent of those suggestions were put into practice, yielding an estimated saving of $5.5 million (Black, 1999). While there are many contributing factors to the above success, most organizational theorists seem to agree that without the commitment and the support of the leadership in nurturing a committed, skilled, and autonomous workforce, many of the achievements may go unseen. Organizations that have carefully aligned their long-term interests with those of the workers will outperform those that are short sighted or those which often ignore the well-being of the workers.

Results of this study provided additional evidence on the new work practices, particularly in the area of Japanese manufacturing techniques. 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.

The findings of this study, while providing insight into the interaction effects 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, although stress has often been cited as one important side effect of the JIT manufacturing, it was not examined in the present study. Future studies can examine the level of stress and its effect on performance in a cross-sectional study. Finally, additional features of incentives can be investigated, including tournament vs. cooperative, monetary vs. non-monetary, and pay vs. promotion.

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, using the cutoff point of annual sales of $10 million and above, there were slightly over 5000 plants in the population. Accordingly, the distribution of the sample by geographic region was compared to that of a random sample of 3,000 electronic plants. 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 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 the reliance on self-report measures. Secondary sources were not available to verify the reported data. 🕮

**Appendix A - Questionnaire**

I. 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

ii. 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

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

QUALITY

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

DELIVERY

- On-time delivery

CYCLE TIME

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

iv. Performance Goals

Does your firm set specific numeric targets for the following performance measures? (Anchoring on “Yes” or “No”)
Note: Performance goals have the same performance measures as used in attention-directing feedback, item IV above.

v. Empowerment

(Anchored by 1=Strongly Disagree, 4=Neither Disagree Nor Agree, and 7=Strongly Agree)
1. Daily problems have been handled primarily by groups.
2. Group members actively provide input to both product and process design.
3. Vacation, back-up process, or unexpected changes in schedule are decided by work group members.
4. In our plant, group members are encouraged to generate input for hiring decisions within their groups.

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