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The role of performance measures and incentive systems in relation to the degree of JIT implementation

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Abstract

The shift to world-class manufacturing strategies has necessitated complementary changes in management accounting systems (MAS). Using survey data obtained from top manufacturing executives at 253 US firms, this study empirically examines the relationship between the level of just-in-time (JIT) practices implemented by US manufacturing firms and the performance measures and incentive systems that are incorporated in their MAS. The statistical tests provide empirical evidence that the use of non-traditional performance measures such as bottom-up measures, product quality, and vendor quality, as well as incentive systems of employee empowerment and compensation rewards for quality production are related to the degree of JIT practices implemented.

1. Introduction

An appropriate organizational structure, incorporating the management accounting system (MAS), is considered a necessity for the successful implementation of organizational strategy (Brickley, Smith, & Zimmerman, 2001; Oldham & Tomkins, 1999). As organizations adapt to technological change, globalization, and customer demand, they must ensure that the MAS is designed congruent with decision-making and control requirements. Recent studies have emphasized that "[s]trategic priorities should be supported by appropriate and effectively implemented manufacturing processes and information systems, including those providing management accounting information" (Chenhall & Langfield-Smith, 1998b, p. 243). Bouwens and Abernethy (2000) address this issue in the context of customization strategies. To date, relatively little research has examined what design of the MAS, organizational structures, and contexts is consistent with the adoption of lean manufacturing systems, such as JIT (Selto, Renne, & Young, 1995).

The shift to world-class, integrated manufacturing strategies, including a JIT management philosophy, requires accompanying changes in the management accounting systems (MAS) that support their implementation (Milgrom & Roberts, 1995; Safayeni, Purdy, Van Engelen, & Pal, 1991; Young & Selto, 1993). JIT's focus on excellence through continuous improvement requires a decision-making system that evaluates the changes in quality, setup times, defects, rework, and throughput time. The MAS also must provide the requisite control systems to motivate organizational members in terms of JIT strategies. Young

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and Selto (1993) suggest that both management and researchers must better understand the types and usages of management controls that are crucial to measuring the success of manufacturing strategies. In a JIT environment, the control system should be linked to critical success factors at all organizational levels, but as Langfield-Smith (1997) and Mia (2000) discuss, the need for performance measurements as controls is particularly important at the operational level of the organization.

The purpose of this study is to evaluate empirically the relationship between the JIT practices implemented by US manufacturing firms and their respective systems for decision making and control, specifically the performance measures and incentive systems that these firms use. The study contributes to the management accounting literature in a number of ways. First, it responds to the call for further survey research that focuses on the combination of strategy, management techniques, and management accounting (Chenhall & Langfield-Smith, 1998b). Through hierarchical multiple linear regression (MLR), the current study finds a significant statistical relationship between the implementation of a JIT strategy and the adoption of non-traditional performance measurement and incentive systems within the MAS. Second, rather than arbitrarily classifying firms into JIT or non-JIT categories, a contribution of this study is its provision of a comprehensive assessment of JIT implementation by capturing the *degree* to which manufacturing firms have implemented 10 basic practices supporting the JIT philosophy. Research has found that the more extensive the adoption of JIT in both breadth and depth, the greater are its benefits (Fullerton & McWatters, 2001; White & Prybutok, 2001). Third, the research extends Chenhall and Langfield-Smith (1998a), which examined the influence of management accounting on discrete management techniques used to implement manufacturing change programs. While the JIT philosophy is both broad and ambiguous in nature, this study operationalizes JIT in terms of the 10 JIT practices classified and utilized in previous research (Fullerton & McWatters, 2001; White, Pearson, & Wilson 1999; White & Prybutok, 2001; White & Ruch, 1990). Specifically, the research examines the management accounting control system that supports JIT implementation. The next section examines the prior literature related to JIT and the MAS, and outlines the research hypotheses. Section 3 describes the research method. Sections 4 and 5 present and discuss the empirical results. The final section summarizes the study, and identifies limitations and future research directions.

2. Research hypotheses

2.1. The JIT manufacturing environment

JIT is a Japanese-developed manufacturing philosophy emphasizing excellence through the continuous elimination of waste and improvement in productivity. According to Schonberger (1987, p. 5), JIT is the "most important productivity enhancing management innovation since the turn of the century." Manufacturing firms have been trying to duplicate this manufacturing system for over two decades, often under different names, e.g. total enterprise manufacturing, world-class manufacturing, and lean production (White & Prybutok, 2001). JIT continues to be referred to as a "revolution in world manufacturing," which, with the help of the Internet, is making dramatic changes to the traditional production system (Zurawski, 2001). In an *Industry Week* survey, almost 95% of corporate executives identified lean manufacturing (defined as manufacturing practices of preventive maintenance, cellular manufacturing, focused factory, continuous flow, reduced lot sizes, quick changeover times, and *kanban*) as either extremely critical or somewhat critical to achieving world-class manufacturing status (Jusko, 1999).

The wasteless production philosophy underlying JIT is "continual productivity and quality improvement in the pursuit of excellence in all phases of the industrial cycle" (White & Ruch, 1990, p. 12). JIT is expected to reduce manufacturing costs continuously through better quality, lower inventory, and shorter lead times. Achieving these results requires an even production flow of small lot size incorporating schedule stability, product quality, short setup times, preventive maintenance, and efficient process layout (Chapman & Carter, 1990; Foster & Horngren, 1987; Hall & Jackson, 1992).

Previous research frequently has classified firms as JIT or non-JIT based on their use of "continuous manufacturing" or a "pull system" (e.g. Balakrishnan, Linsmeier, & Venkatachalam, 1996; Kalagnanam & Lindsay, 1998). However, classification as a "JIT firm" can range from the implementation of an inventory management system to the total integration of JIT practices throughout the manufacturing system. Confusion remains over what exactly constitutes JIT (Mia, 2000); yet the manufacturing practices of "efficient material flow, improved quality, and increased employment involvement" continue to be sought-after, competitive strengths of world-class manufacturing firms. JIT remains the most "universally accepted term to describe this broad production system" (White & Prybutok, 2001, p. 113). Many firms may practice a majority of JIT practices, as defined in this study, without identifying themselves as JIT firms.

In order to optimize overall organizational performance, a systems perspective that employs each element of JIT should be implemented (Suzaki, 1987). "The potential synergic benefits are not fully realized until all elements of a JIT system are integrated" (White & Prybutok, 2001, p. 114). A recent survey reported that purchasing managers "still believe heartily in JIT," but companies need to more fully implement material flow and quality management activities to reap its full benefits (Milligan, 2000). The current study examines the *degree* of JIT implementation by capturing the extent to which sample firms have adopted a combination of JIT elements. These data allow for a comprehensive assessment of JIT implementation as a broad, integrated production system.

Despite the acute awareness of JIT and its purported benefits, its implementation by US firms has been relatively slow and in an ad hoc fashion (Clode, 1993; Gilbert, 1990; Goyal & Deshmukh, 1992). The implementation lag has been attributed to a number of factors: the resistance to change, inadequate understanding of JIT methods, a tendency to implement only its easiest and least costly elements, an incompatible workforce and workplace environment, and non-supportive suppliers (Majchrzak, 1988; Snell & Dean, 1992; Wafa & Yasin, 1998; White & Prybutok, 2001). An alternative explanation for JIT's limited success in the USA is the failure of the MAS to provide appropriate performance measures and incentives to support JIT objectives. In their in-depth, cross-sectional study of a JIT firm, Young and Selto (1993) found that although information related to critical success factors was well designed and available, this information was not provided at the shop-floor level where it could affect operating decisions.

2.2. The role of the management accounting system

Implementing JIT creates major changes in an organization's way of doing business. These changes should be reflected in the MAS that provides the necessary information for improved decision making and control. This information also should enhance firm productivity by motivating employees in terms of the organization's strategic goals (Sprinkle, 2000). However, the MAS information often can be misleading in this new environment.

> The preoccupation with efficiency and cost reduction at the expense of effectiveness forces managers to adopt short-term operational views that detract attention from the crucial manufacturing strategy and structure and alienate the work force (Lee, 1987, p. 84).

For almost two decades, academics and popular business authors have proclaimed the obsolescence and ineffectiveness of current management accounting and business performance measures in advanced manufacturing environments (i.e. Green, Amenkhienan, & Johnson, 1992; Hedin & Russell, 1992; Hiromoto, 1991; Howell & Soucy, 1987; Johnson & Kaplan, 1987; Mazachek, 1993; McNair, Lynch, & Cross, 1990; McNair, Mosconi, & Norris; 1989; Neely, 1999; Sillince & Sykes, 1995; Wisner & Fawcett, 1991). Due to their short-term emphasis, current measures do not provide an accurate assessment of improvements that affect long-term profitability (Hendricks, 1994; Ittner & Larcker, 1998; Johnson & Kaplan, 1989; Kaplan, 1983; Kaplan & Norton, 1996). "Measures have always had the power to shape a corporation's destiny, but the focus on financial figures alone limits their utility. Management accounting of the past forced managers to build world-class organizations with a truncated set of chromosomes" (Epstein & Birchard, 2000, p. 145).

When systems reward managers and employees for efforts counterproductive to JIT, instead of for efforts designed to increase quality, eliminate waste, and reduce throughput time, the wrong incentives are communicated. A firm will implement JIT more successfully, as well as obtain information requisite to improving its competitive position, if its performance measures concentrate on inventory levels, throughput, lead time, defect rates, equipment downtime, and employee training (Wisner & Fawcett, 1991). "The pursuit of manufacturing strategies focused on quality and flexibility...[has] implications for both the range of strategic performance measures and the importance of non-financial measures" (Lillis, 1999, p. 17).

To operate at peak performance, advanced manufacturing firms must retool their MAS (Epstein & Birchard, 2000), making waste visible at all levels and integrating performance measurements with continuous-improvement processes (Maskell, 2000). The lack of slack and cushion in a JIT environment renders MAS information on targets and actual performance more critical than in non-JIT situations (Mia, 2000). Benefits from JIT implementation, therefore, are enhanced by complementary changes in a firm's internal accounting measures (Ahmed, Runc, & Montagno, 1991; Ansari & Modarress, 1986; Barney, 1986; Bennett & Cooper, 1984; Hendricks, 1994; Milgrom & Roberts, 1995). The management accounting profession is responding to the need for MAS modifications that will increase global competitiveness. Recent changes have been described as a performance measurement revolution that seeks to redress the insufficiency of traditional performance measures for evaluating advanced manufacturing techniques (Neely, 1999).

Extensive discussion exists of the association between increased reliance on non-financial performance measures and strategic manufacturing change (Lillis, 1999). Previous studies have indicated that organizations using more efficient production practices make greater use of non-traditional information and reward systems (Abernethy & Lillis, 1995; Banker, Potter, & Schroeder, 1993a, 1993b; Durden, Hassel, & Upton, 1999; Ittner & Larcker, 1995, 1998; Jazayeri & Hopper, 1999; Patell, 1987). World-class manufacturing systems—advanced manufacturing technology, TQM, and JIT— have been referred to and examined in research studies in isolation and as synergistic combinations (Flynn, Sakakibara, & Schroeder, 1995; Patell, 1987; Sim & Killough, 1998; Snell & Dean, 1994; Swanson & Lankford, 1998). Ittner and Larcker (1995) looked exclusively at the relationship between TQM practices and non-traditional information and reward systems, and found variates from both TQM practices and non-traditional accounting measures that were significantly related. Banker et al. (1993a, 1993b) found a positive relationship between the accessibility of non-financial information on the shop floor and the implementation of both TQM and JIT practices. Sim and Killough (1998) extended Ittner and Larcker (1995) with a focus on both TQM and JIT, but did not look at the direct relationship among performance measures, JIT, and TQM. Instead, these three measures were independent variables used to explain plant-wide customer and quality performance.

Although evidence shows the MAS is expanding to include more non-financial information, the majority of firms still use traditional accounting criteria much more than non-traditional for both internal and external performance evaluation (Ittner & Larcker, 1998; Mazachek, 1993). The current study extends existing research related to world-class manufacturing practices and their relationship to performance measures by examining the linkage between the degree of JIT implementation in US manufacturing firms and the use of non-traditional performance measures and incentive systems.

2.3. Hypothesis 1A

To make decisions in a JIT environment, a firm must measure and report those items that are affected by JIT adoption (i.e. inventory turns, delivery time, scrap, quality, setup times, and vendor performance). Young (1992) points out that without appropriate measures to evaluate and control the critical measures of success in a JIT system, its level of performance could be incorrectly assessed. According to Foster and Horngren (1987), JIT firms depend less on financial measures and more on personal observations and non-financial measures. In their 1991 study of Japanese companies, Daniel and Reitsperger found that setup times, scrap, and downtime were reported more frequently to managers supporting zero-defect strategies than managers supporting more traditional strategies. Banker et al. (1993b) concluded that when quality improvement strategies were implemented, non-financial information to workers was more available. Results in a related study by Banker et al. (1993a) indicated that the availability and use of productivity measures were related to the implementation of JIT and TQM.

Ittner and Larcker (1995, 1997b) recommended that the distribution of information encompass all levels of the organization to overcome the deficiencies of the MAS. Workers need to gather their own "bottom-up" information using statistical process control (SPC), Pareto analysis, histograms, and flow charts, rather than be dependent upon "top-down" information that emphasizes standards and budgets (Johnson, 1992). Ittner and Larcker (1998) reported more extensive use of non-financial performance measures to supplement traditional accounting-based measures. A case study of a UK chemical company implementing world-class manufacturing practices found that non-financial measures such as quality, on-time delivery, inventory levels, and productivity replaced the previous emphasis on budgets and financial measures (Jazayeri & Hopper, 1999). However, the specific link between the degree of JIT implementation and the use of non-traditional performance measures and incentive systems is not clear. Hypothesis 1A examines this relationship:

H_{1A}. Firms implementing a higher degree of JIT elements such as lean manufacturing practices, quality improvements, and *kanban* systems are more likely to use more non-traditional performance measures of quality results, bottom-up data, benchmarking, waste, and vendor quality.

2.4. Hypothesis 1B

If firm incentives are not aligned with organizational changes, the desired behaviors for new, integrated manufacturing systems are difficult to achieve (Lawler, 1981; Snell & Dean, 1992, 1994). Compensation incentives for all employees need to be linked to organizational strategy. Reward systems also must be congruent with other organizational systems, with alignment necessary among the organization's core values, its processes, its practices, and its structures (Lawler, 1998, p. 288). In an advanced manufacturing environment, reward systems should reflect critical success factors of product quality and team-based performance (Ittner & Larcker, 1995).[1] Reitsperger (1986) found that workers in Japanese-managed corporations outperformed their counterparts in US- and UK-managed companies, because incentive pay was tied to quality and productivity measures.

Despite the call for more broadly based strategic measures, the majority of firms rely on traditional financial performance measures as compensation incentives. Mazachek (1993) demonstrated that managers considered accounting criteria to be significantly more important than non-accounting criteria as indicators of firm performance and evaluators of managerial performance. Ittner and Larcker's (1998) review of trends in performance measurement reiterated this point. Hypothesis 1B examines the link between compensation rewards and non-financial measures in a JIT environment.

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[1] The relationship between reward systems and advanced manufacturing systems is not a clear cut one, as noted by Lawler, Mohrman, and Ledford (1992, p. 102): "The total quality literature has in some cases (Deming, 1986) cautioned against 'management by fear' and especially against the establishment of individual appraisal systems and standards of performance. The argument is that these fail to take account of the reality that performance levels are more the product of the system than of individual performance. As a result, practices that manage the performance of individuals have not been a central focus of implementation in total quality management." Lawler et al. include JIT as part of the total quality system.

$\mathbf{H_{1B}}$. Firms implementing a higher degree of JIT elements such as lean manufacturing practices, quality improvements, and *kanban* systems are more likely to tie compensation rewards to non-financial measures.

2.5. Hypothesis 1C

Previous research has emphasized that the successful adoption of advanced manufacturing systems is linked to human resource management practices (Snell & Dean, 1992). JIT is designed to show respect for people by using their input in decision making and broadening their workplace skills (Billesbach & Hayen, 1994; Golhar, Stamm, & Smith, 1990; Johnston, 1989; Plenert, 1990; Schonberger, 1982; Snell & Dean, 1992). Wruck and Jensen's (1994) analysis of TQM is pertinent here. Their study outlines TQM's association with employee empowerment in that both TQM and empowerment require firms "to effectively utilize valuable specific knowledge at lower levels of the organization" (p. 258).

Empowerment in decision making, however, has different implications for a JIT environment. Although JIT might limit employee discretion in production-level decisions, it generally increases responsibility in the areas of operations and quality control (Snell & Dean, 1992, p. 494). The top-down nature of JIT implementation affects some aspects of employee empowerment and may contribute to the conflict between reduced discretion in JIT environments and the need for responsive operational decision-making (Klein, 1989, 1991).

In a JIT environment, strategic priorities need to be communicated throughout the firm, such that quality improvements support organizational strategy. Measurement data should be linked to corporate strategies (Govindarajan & Gupta, 1985; Ittner & Larcker, 1997b; Kaplan & Norton, 1996; Najarian, 1993; Perera, Harrison, & Poole, 1997). Employees should not only be better informed, but also have the ability to make operating decisions. Ittner and Larcker (1995, p. 6) suggested that "the primary role of MAS in TQM environments is providing empowered workers with information for problem solving and continuous improvement activities." In a JIT environment, the workers are put in control of production operations, which requires their involvement in solving production problems (Banker et al., 1993a). Thus, the MAS must provide information that enables effective worker empowerment. Hypothesis 1C examines the effect of JIT implementation on the role of employees.

$\mathbf{H_{1C}}$. Firms implementing a higher degree of JIT elements such as lean manufacturing practices, quality improvements, and *kanban* systems are more likely to have increased empowerment in decision making and a clearer understanding of company strategy.

3. Research method

3.1. Survey instrument

To examine these relationships, a five-page survey instrument was used to collect specific information about the manufacturing operations, product-costing methods, information and incentive systems, JIT practices employed, perceived results from JIT implementation, and characteristics of the respondent firms. The survey was sent to executives representing 447 US manufacturing firms. Data from the 253 survey responses were analyzed to determine whether the implementation of JIT practices is linked to non-traditional performance measures and incentives in the MAS.

The majority of the questions on the survey instrument are either categorical or interval Likert scales. Factor analysis combined the Likert-scaled questions into independent measures for testing the research question. The survey instrument was evaluated in a limited pretest by several business professors and managers from five manufacturing firms for readability, completeness, and clarity. Appropriate changes were made as per their comments and suggestions.

3.2. Sample firms

To select sample JIT firms, an extensive literature search was done to identify all of the US manufacturing firms thought to be formally practicing

JIT. A potential sample of additional US manufacturing firms was located on Compaq Disclosure. For inclusion in the study, a firm was required to have a primary two-digit SIC code within the manufacturing ranges of 20 and 39, have sales between \$2 billion and \$2 million, and be included on the COMPUSTAT database.[2] After eliminating the randomly selected firms from this sample because of duplication or inadequate COMPUSTAT information, manufacturing executives at 447 firms were sent the survey packet.

In contacting the potential respondents, the purpose of the survey was explained, along with a request for participation. The objective was to locate the most senior manufacturing person who had a broad enough understanding of operations to complete the questionnaire. Sometimes the executive would forward the survey to or supply the name of another individual who could better answer the questionnaire. A number of the respondents indicated that they had requested information from other personnel to complete the questionnaire. Thus, evidence exists that serious efforts were made to answer the survey questions appropriately. Following a maximum of three contacts, 254 out of the 447 firms surveyed completed and returned the survey instruments, for an overall response rate of 56.8%.[3,4] The respondents had an average of 17 years of management experience, including 9 years in management with their current firm and various levels of responsibility (see Table 1 for distribution of respondents).

The industry distributions of the self-identified JIT, non-JIT, and total sample respondent firms are presented in Table 2. The majority (72%) of the respondent firms are from four industries: chemicals and allied products (SIC-28), industrial machinery (SIC-35), electronics (SIC-36), and instrumentation (SIC-38).[5]

3.3. Measuring the degree of JIT implementation

Without assuming directional causality, *the degree of JIT practices implemented* operates as the dependent variable to test the linear equation for the research hypotheses. An objective of this study is to specify and measure a representative set of JIT manufacturing practices. Thus, it was necessary to delineate a set of measurable manufacturing practices describing JIT. The struggle to define JIT stems from an inability to specify a universal set of elements (White & Ruch, 1990). Different

Table 1
Distribution of survey respondents

Title	Number
VP manufacturing or operations	51
Manufacturing or operations director	43
Manufacturing/production managers	41
Quality assurance managers	30
VP quality	24
Quality director	21
President/CEO	17
Plant manager	17
Miscellaneous or undesignated	10
Total	254

[2] It was determined that surveying one person in companies with annual sales in excess of \$2 billion about the overall practices in his or her company was problematic. In addition, firms with annual sales of less than \$2 million were determined to be non-representative. However, seven firms in excess of \$2 billion were actually sampled, with four responding. These larger firms were included in the sample because they were pre-identified as JIT firms and a contact person (manufacturing executive) was known.

[3] The means of the sales for non-responding and responding firms were compared to determine if there was a response bias related to the size of the firms. The mean of the sales from the responding firms is slightly higher at \$404 million, than that of the sales from the non-responding firms at \$380 million. However, an ANOVA test shows the differences in the means for responding and non-responding firm sales are not statistically significant. In addition, the means of the industry SIC codes (represented as dummy variables) for the non-responding and responding firms were compared. An ANOVA test shows no statistical differences in the industry means between the responding and non-responding firms. Thus, there does not appear to be a response bias related to either firm size or industry.

[4] Perhaps one reason for the higher than usual response rate for this type of research is the respondents' interest in the material. Eighty percent of those responding (192) requested a copy of the research results.

[5] The industry distribution for the respondent firms is similar to the total sample industry distribution. Seventy percent of the firms sampled were from these same four industries: chemicals and allied products, industrial machinery, electronics, and instrumentation.

Table 2
Distribution of two-digit SIC codes for sample firms

Industry	JIT firms frequency	Non-JIT firms frequency	Sample frequency	Sample per cent
20—Food	1	6	7	2.8
22—Textiles	2	3	5	2.0
25—Furniture and fixtures	5	1	6	2.4
26—Paper and allied products	1	1	2	0.8
27—Printing/publishing	1	0	1	0.4
28—Chemicals and allied products	4	20	24	9.5
30—Rubber products	3	2	5	2.0
33—Primary metals	3	12	15	5.9
34—Fabricated metals	7	7	14	5.5
35—Industrial machinery	17	24	41	16.2
36—Electronics	24	37	61	24.1
37—Motor vehicles and accessories	6	5	11	4.3
38—Instrumentation	20	35	55	21.7
39—Other manufacturing	1	5	6	2.3
Totals	95	158	253	100.0

practices deemed important in adopting JIT are iterated in several studies (Banker et al., 1993a, 1993b; Flynn et al., 1995; Mehra & Inman, 1992; Moshavi, 1990; Spencer & Guide, 1995; Young, 1992). Moshavi (1990) suggests five essential elements of JIT: setup time reduction, focus flow processing, containerization (pull system containers for inventory), parts control (*kanban*), and preventive maintenance. Young (1992) discusses the JIT manufacturing system, *kaizen*, total quality control, and JIT purchasing as important underlying factors of the Japanese manufacturing system. A literature review through 1990 by White and Ruch found 16 techniques identified as JIT. A consensus for 10 of these JIT elements was iterated by established JIT authors (e.g. Hall, Hay, Monden, Schonberger, Shingo, and Suzaki). These consensus elements are described in previous research as encompassing JIT practices and are used by White et al. (1999; White & Prybutok, 2001) and Fullerton and McWatters (2001) as JIT indicators. Thus, they were considered broad enough to represent a comprehensive JIT implementation for the purposes of this study. The 10 items employed to measure the extent to which a company has adopted JIT are: *focused factory*, *group technology*, *reduced setup times, total productive maintenance, multi-function employees, uniform workload, kanban, JIT purchasing, total quality control, and quality circles*.[6]

3.3.1. Factors for JIT determinants

Eleven six-point Likert-scaled questions on the survey instrument measure the extent to which firms use JIT.[7] Responses from the 11 JIT-implementation questions were refined with an exploratory factor analysis using the principal components method. Three components of JIT with eigenvalues greater than 1.0 were extracted

[6] Further research is necessary to determine which JIT elements are most important for successful JIT implementation and how these JIT elements interact. It is not possible to make these determinations from the data gathered in the current study. However, Table 6 indicates the degree to which the individual elements have been implemented by the sample firms and the largest implementation differences between JIT and non-JIT firms. In addition, the factor loadings of the individual JIT measurement variables reported in Table 3 assist in the understanding of how these individual JIT practices are related. Finally, each of the three identified JIT constructs in the factor analysis is significantly correlated with the other two. Although it is impossible to determine *how* they interact, it is apparent that they do.

[7] Total quality control is represented by two questions on the survey: one is related to process quality and the other to product quality.

Table 3
Factor analysis (VARIMAX rotation) and factor loadings for JIT variables[a]

	Factor 1 JITMANUF	Factor 2 JITQLTY	Factor 3 JITUNIQUE
Cronbach's alpha	0.831	0.946	0.684
Focused factory	0.740		
Group technology	0.770		
Reduced setup times	0.706		
Productive maintenance	0.668		
Multi-function employees	0.501		
Uniform work load	0.731		
Product quality improvement		0.917	
Process quality improvement		0.902	
Kanban system			0.820
JIT purchasing			0.825

[a] All loadings in excess of 0.300 are shown. $n = 253$.

from the analysis, representing 63% of the total variance in the data.[8]

The first factor is a manufacturing component that explains the extent to which companies have implemented general manufacturing techniques associated with JIT, such as focused factory, group technology, uniform work loads, and multi-function employees. Together these represent elements of a JIT manufacturing philosophy, although individual elements of the factor may be adopted by any high technology manufacturing firm.

The second JIT factor is a quality component that examines the extent to which companies have implemented procedures for improving product and process quality. A reason for the association between TQM and JIT is their common continuous improvement goals. Successful JIT implementation requires a high level of quality in production. Although TQM can be adopted without implementing JIT, it is unlikely that a JIT manufacturing system can succeed without incorporating the underpinning tenets of TQM. Good quality management and productive maintenance are keys to JIT survival (Imai, 1998). Quality frequently has been referred to as the cornerstone of JIT (Banker et al., 1993a; Sim & Killough, 1998; Swanson & Lankford, 1998; Young et al., 1988).

The third JIT factor identified is one of uniquely JIT practices that describe the extent to which companies have implemented JIT purchasing and *kanban*. The likelihood is low that companies who are not fully committed to a JIT program would adopt these practices. A description of the specific survey questions that support these factors is found in Appendix B. For results of the factor analysis for JIT elements, refer to Table 3.

3.4. Independent variables

Nine constructs were selected to examine the non-traditional performance measures and incentive systems of manufacturing firms. Four of these constructs, which represent performance measures for evaluating manufacturing productivity, measure hypothesis 1A: *bottom-up data gathering techniques*; *benchmarking for products*, *services*, *and processes*; *frequency of measurements and reports on quality*; *and manufacturing performance measures*. The first three of these constructs were defined in Ittner and Larcker's 1995 TQM study. The last construct is similar to one examined by Durden et al. (1999) in examining the use of non-financial manufacturing performance indicators in a JIT environment. Three constructs related to

[8] All of the 11 elements loaded greater than 0.50 onto one of the three constructs except for number 11, asking about the use of "quality circles". It was evident from initial observations of the survey responses that only a few firms (both JIT and non-JIT) used quality circles. Thus, this question was eliminated from further testing representing JIT.

performance incentives through compensation are examined in hypothesis 1B: *compensation ties to non-financial performance*; *compensation ties to quality and team performance*; *and compensation ties to traditional profitability measures*. The last two constructs of the research analysis testing hypothesis 1C are: *communication of the strategic plan to middle managers, first-line supervisors, and non-management personnel*; *and empowerment of employees in decision making*.

3.4.1. Factors for performance measures and incentive systems

Thirty-nine items from the survey instrument were evaluated to measure the nine performance-measure and incentive-system constructs. To reduce and summarize the collected data, these survey items were subjected to a factor analysis. Using the principal components method, the factor analysis revealed ten distinct factors with eigenvalues greater than 1.0, which accounted for 73% of the total variance in the data.[9] The VARIMAX rotation resulted in the following factors:

QLTYREV: The frequency with which quality issues are measured and reported to management strata.
COMPQLTY: The importance of quality and teamwork in determining compensation.
BOTTOM: The use of bottom-up data gathering techniques such as Pareto analysis, histograms, and cause-and-effect diagrams to evaluate operations.
COMPBDGT: The importance of adherence to budget items in determining compensation.
BENCH: The use of benchmarking to evaluate operations.
PERFWASTE: The use of performance measures related to waste and inefficiency in evaluating the manufacturing system
STRPLAN: The extent to which employees understand the firm's strategic plan.
PERFVEND: The use of performance measures related to timeliness and vendor performance in evaluating the manufacturing system.
COMPNF: The use of non-financial measures to determine compensation.
EMPOWER: The extent to which line managers and non-management personnel are empowered to make decisions.

A description of the specific survey questions that support these factors is found in Appendix A. For the results from the factor analysis, refer to Table 4.

3.5. Control variables

Four control variables (covariates) are included in the regression testing. *Firm size* (SIZE) affects most aspects of a firm's strategy and success; therefore a firm's net sales are used to control for firm size. The net sales for each sample firm are obtained from COMPUSTAT data. Whether a firm follows a more innovative strategy can affect its willingness to make changes. Innovative firms are more risky and generally more profitable (Capon, Farle, & Hoenig, 1988). *Innovation* (INNOV) is measured by a firm's response on the survey instrument as to whether it is a leader or a follower in product technology, product design, and process design (Ittner & Larcker, 1995). The industry in which a firm operates often affects its competitive behavior and performance measures. Thus, the *industry* for each firm, as identified on COMPUSTAT, is tested by the use of the firm's two-digit SIC code (SIC). Organizational structure can influence a firm's ability to be flexible and

[9] Seven factors loaded as expected (QLTYREV, BOTTOM, BENCH, COMPQLTY, COMPNF, STRPLAN, and EMPOWER). The construct for evaluating compensation rewards from traditional financial measures loaded onto two factors. One was for compensation incentives related to variances and budgets, which created the COMPBDGT variable. The other factor was for compensation rewards related to traditional profitability measures. This factor made no significant contributions to any of the regression tests; therefore, it was eliminated from the final analyses. The expected single construct measuring manufacturing performance loaded onto two factors as per the factor analysis: PERFWASTE and PERFVEND.

Table 4
Factor analysis (VARIMAX rotation) and factor loadings for performance measures and incentive systems variables[a]

	Factor 1 QLTYREV	Factor 2 COMPQLTY	Factor 3 BOTTOM	Factor 4 COMPBDGT	Factor 5 BENCH	Factor 6 PERFWASTE	Factor 7 STRPLAN	Factor 8 PERFVEND	Factor 9 COMPNF	Factor 10 EMPOWER
Cronbach's alpha	0.920	0.909	0.873	0.862	0.907	0.775	0.828	0.783	0.869	0.809
TM reviews quality results	0.719									
TM reviews quality consequences	0.793									
MM reviews quality results	0.836									
MM reviews quality consequences	0.857									
LS reviews quality results	0.819									
LS reviews quality consequences	0.828									
MM compensation—quality		0.773								
MM compensation—throughput		0.703								
MM compensation—teamwork		0.734								
LS compensation—quality		0.854								
LS compensation—throughput		0.827								
LS compensation—teamwork		0.783								
Use cause-and-effect diagrams			0.729							
Use histograms			0.791							
Use flowcharting			0.658							
Use Pareto analysis			0.778							
Use scatter diagrams			0.748							
Use SPC charts			0.652							
MM compensation—variances				0.788						
MM compensation—budget				0.704						
LS compensation—variances				0.794						
LS compensation—budget				0.780						
Benchmarking of operations					0.844					
Benchmarking of products					0.867					
Benchmarking of delivery systems					0.836					
Performance measures—downtime						0.691				
Performance measures—scrap						0.721				
Performance measures—rework						0.689				
Performance measures—setups						0.685				
MM understand strategic plan							0.791			
LS understand strategic plan							0.793			
NM understand strategic plan							0.776			
Performance measures—on-time								0.514		
Vendor performance—quality								0.866		
Vendor performance—on-time								0.879		
MM compensation—non-financial									0.867	
LS compensation—non-financial									0.873	
LS empowerment										0.713
NM empowerment										0.741

[a] All loadings in excess of 0.300 are shown. $n=253$. TM = top management; MM = middle management; LS = line supervisors; NM = non-management.

make major operational changes. If a firm is highly centralized, the employees will be much less involved in decision making and organizational changes than if it is more decentralized. Kalaganam and Lindsay (1998) demonstrated how adapting more organic (decentralized) organizational structures led to greater benefits from JIT adoption. The *organizational structure* (STRUCTR) of a firm is identified on the questionnaire.

3.5.1. Factors for control variables

The six survey questions related to firm innovation and organizational structure were reduced and summarized using factor analysis. These six variables converged into two anticipated distinct factors with eigenvalues in excess of 1.0, accounting for 66% of the total variance in the data. The VARIMAX rotation resulted in the following control variables:

STRUCTR: The extent of centralization or decentralization of a firm's organizational structure.

INNOV: The extent to which the firm considers itself a leader in product and process design and product technology.

A detailed description of the specific questions that support these control variables is found in Appendix B. Refer to Table 5 for the rotated factor solution.

3.6. Construct validity and reliability analysis

The factor solutions for the defined constructs support the construct validity of the survey instrument. Convergent validity is demonstrated by each factor having multiple-question loadings in excess of 0.5. In addition, discriminant validity is supported, since none of the questions in the factor analyses have loadings in excess of 0.3 on more than one factor.[10] Cronbach's alpha is used as the coefficient of reliability for testing the internal consistency of the constructs validated by the factor analysis. The alpha coefficients for all of the constructs are in excess of 0.7.[11] (The alpha coefficients are included in Tables 3–5.) Overall, these tests support the validity of the measures representing the constructs used in this study.

4. Research results

4.1. Descriptive statistics

One objective of this study is to capture the degree to which the sample firms have implemented JIT practices. On the survey instrument, the respondents were asked to provide the degree to which they were using 10 individual aspects of JIT (scaled from 1 to 6). Respondents also were asked to indicate whether their firm had formally implemented JIT. Descriptive statistics depicting the means for each of the individual elements, along with the three JIT factors, and the total combination of the JIT elements are shown on Table 6. The data are presented in terms of the total sample, the JIT sample firms, and the non-JIT sample firms.

The ANOVA comparison of the means between the JIT and non-JIT firms, found on Table 6, consistently shows highly significant differences ($p<0.000$) between JIT and non-JIT firms. For each JIT measure, the mean for the JIT firms exceeds 3.6, whereas only three of the individual elements of the non-JIT firms have a mean greater than 3.1. JIT firms have an average mean of 4.448 for all JIT elements combined, compared to 3.357 for non-JIT firms ($F=109.098$, $p<0.000$). The results provide statistical evidence that the items represented by the individual factors used to explain the degree of JIT implementation are adopted more fully by firms classifying themselves as JIT, although it is not possible to determine which of these JIT practices result from a specific JIT strategy.

[10] In order to further test the construct validity of the resulting constructs, all of the initial factor structures were cross validated through the use of split samples (firms either declared as having implemented JIT or those that had not). Similar loadings in the cross-validation samples verified the initial underlying patterns.

[11] According to Nunnally (1978), alpha coefficients of 0.5–0.6 are acceptable for exploratory research. Efforts to increase reliability above 0.8 are often wasteful for basic research.

JIT is recognized as a long-term initiative. All of the means, except for the quality practices, are approximately 4.0, indicating partial implementation. Twenty of the 105 firms responding to the survey question regarding the year of JIT implementation were in their initial year of implementation and 16 were in their second year. The median year of practicing JIT for these firms was three years. Thus, JIT is a new initiative for many of the sample firms.

Quality management has been recognized as a necessary component in successful JIT implementation. The highest means of the JIT factors are for the adoption of quality practices. The

Table 5
Factor analysis (VARIMAX rotation) and factor loadings for control variables[a]

	Factor 1 STRUCTR	Factor 2 INNOV
Cronbach's alpha	0.793	0.677
Organizational structure—overall company	0.703	
Organizational structure–individual operations	0.877	
Organizational structure—individual departments	0.844	
Firm's innovation strategy in product technology		0.763
Firm's innovation strategy in process design		0.604
Firm's innovation strategy in product design		0.815

[a] All loadings in excess of 0.300 are shown. $n=253$.

Table 6
Descriptive statistics for JIT constructs and comparison of means between JIT firms and non-JIT firms[a]

	Full sample means	JIT firms means	Non-JIT firms means	ANOVA F-value	Sig. F
JITMANUF elements					
Focused factory	3.108	3.905	2.622	35.261	0.000
Group technology	2.976	3.695	2.539	32.070	0.000
Reduced setup times	3.454	4.105	3.058	27.941	0.000
Productive maintenance	3.287	3.958	2.878	30.467	0.000
Multi-function employees	4.235	4.611	4.006	13.036	0.000
Uniform work load	3.051	3.779	2.635	32.058	0.000
JITMANUF factor	3.412	4.055	3.020	54.975	0.000
JITQLTY elements					
Product quality improvement	4.677	5.042	4.455	17.557	0.000
Process quality improvement	4.653	5.011	4.436	16.003	0.000
JITQLTY factor	4.665	5.026	4.446	17.809	0.000
JITUNIQUE elements					
Kanban system	2.920	3.990	2.269	72.068	0.000
JIT purchasing	3.546	4.537	2.942	85.714	0.000
JITUNIQUE factor	3.233	4.263	2.606	114.106	0.000
JIT elements combined	3.770	4.448	3.357	109.098	0.000

[a] Implementation scale for these survey items: No intention = 1; Considering = 2; Beginning = 3; Partially = 4; Substantially = 5; Fully = 6. $n=253$.

means of these two constructs, product and process quality improvement, are both greater than 5.0. These results reinforce earlier research that links the success of JIT implementation to the complementary use of quality initiatives such as TQM (Banker et al., 1993a; Sim & Killough, 1998; Swanson & Lankford, 1998; Young, Shields, & Wolf, 1988).

4.2. MLR regression results

A major reason given for the limited success from JIT implementation is the piece-meal approach that companies use in its adoption (Clode, 1993; Daniel & Reitsperger, 1991; Gilbert, 1990; Goyal & Deshmukh, 1992). To better understand the relationship between a firm's MAS and the degree to which it has implemented JIT, four regression equations are used. Each of the three individual factors of JIT (a manufacturing component, a quality component, and a unique JIT practices component) acts as the dependent variable. In addition, the means of the three JIT factors are added together to represent a holistic view of the dependent variable, *the degree of JIT implementation*. The higher the total arithmetic mean, the higher the degree of JIT implementation assumed.

As encouraged by Stout and Ruble (1995), this study partitions the explanatory variables of the regression testing into subsets. This approach aids in understanding the impact of more discrete explained variances on the relationships examined. Hierarchical MLR is used to test the statistical relationship of various sets of the 10 independent performance measures and incentive system variables and the use of JIT practices.[12] For each regression, the three control variables (STRUCTR, INNOV, and SIZE) are first entered into the equation.[13] In step two, the independent variables related to non-traditional production measures are entered into the equation. Step three adds the compensation variables to the equation. In the last step, the two variables related to employee empowerment are entered.

The regression models are all statistically significant to $p<0.000$, with explained variances ranging from a high of 52% for the overall JIT model to a low of 30% for the unique JIT practices model. The contribution of the control variables and the manufacturing performance variables show a significant relationship at $p<0.000$ with all of the JIT dependent variables, and together these variables account for over 85% of the explained variance in each equation. Step three of the regression adds the compensation variables. The contribution of these variables is significant to all of the JIT relationships, except the unique JIT practices. The last step of employee empowerment also makes a significant contribution to all of the equations, except the JIT quality dependent variable (see Tables 7–10 for MLR results).

Individual explanatory variables that consistently show a significant relationship with the degree of JIT practices include the frequency of using bottom-up measuring techniques (BOTTOM) such as histograms, flowcharting, Pareto analysis, and SPC charts to evaluate operations, and the frequency of measuring and reporting quality results to supervisors and managers (QLTYREV). The control variables of size (SIZE) and innovation (INNOV) also are consistently significant. In addition, strong associations are demonstrated between JIT practices and the compensation variable that represents rewards for enhancing product quality, throughput time, and team performance (COMPQLTY), as well as the two employee empowerment variables (EMPWR and STRPLAN).

[12] Multicollinearity tests were performed to assure independence of the variables. The correlation matrices of the independent variables were examined for evidence of collinearity problems. Although there are several significant relationships among the Pearson correlation coefficients, none of them are sufficiently high enough to suggest serious multicollinearity. In addition, neither the tolerance (TOL) for each variable nor the inflation factor (VIF) shows signs of multicollinearity.

[13] The firm's industry measured by its two-digit SIC code (SIC) also was considered as a control variable. It initially was included in all of the hypotheses testing as a dummy variable for each of the industries represented by the sample firms. No significant contribution was found for the industry effect, either as a collective whole or as individual dummy variables, so SIC was eliminated as a control variable.

5. Discussion

5.1. Hypothesis 1A

The research results provide strong support for hypothesis 1A. In every regression, a significant relationship between the use of JIT practices and non-traditional performance measures exists. In most cases, these measures account for over 50% of the explained variance. The use of bottom-up measures such as SPC charts, flowcharts, and cause-and-effect diagrams are usually associated with TQM.

Table 7
Regression results for the relationship between performance measures and incentives and general manufacturing JIT practices (dependent variable = JITMANUF)[a]

Independent variables		Beta	t	Sig.	R^2	ΔR^2	F	Sig. F
Step 1					0.158	0.158	13.105	0.000
Organizational structure of firm	STRUCTR	0.092	1.428	0.155				
Firm's innovation strategy	INNOV	0.270	4.241	0.000				
Size of firm measured by sales	SIZE	0.240	3.741	0.000				
Step 2					0.411	0.253	17.650	0.000
Organizational structure of firm	STRUCTR	0.032						
Firm's innovation strategy	INNOV	0.144						
Size of firm measured by sales	SIZE	0.089						
Frequency quality results reported	QLTYREV	0.252	4.004	0.000				
Use of bottom-up measures	BOTTOM	0.225	3.575	0.000				
Use of benchmarking techniques	BENCH	0.011	0.171	0.865				
Performance measures of waste	PERFWASTE	0.186	2.870	0.005				
On-time and vendor performance	PERFVEND	0.107	1.771	0.078				
Step 3					0.450	0.038	4.688	0.003
Organizational structure of firm	STRUCTR	0.048						
Firm's innovation strategy	INNOV	0.143						
Size of firm measured by sales	SIZE	0.081						
Frequency quality results reported	QLTYREV	0.231						
Use of bottom-up measures	BOTTOM	0.175						
Use of benchmarking techniques	BENCH	−0.013						
Performance measures of waste	PERFWASTE	0.149						
On-time and vendor performance	PERFVEND	0.080						
Compensation: quality and throughput	COMPQLTY	0.215	3.147	0.002				
Compensation: variances and budgets	COMPBGT	−0.054	−0.829	0.408				
Compensation: non-financial measures	COMPNF	−0.065	−1.078	0.282				
Step 4					0.473	0.024	4.527	0.012
Organizational structure of firm	STRUCTR	0.014						
Firm's innovation strategy	INNOV	0.147						
Size of firm measured by sales	SIZE	0.082						
Frequency quality results reported	QLTYREV	0.268						
Use of bottom-up measures	BOTTOM	0.160						
Use of benchmarking techniques	BENCH	−0.038						
Performance measures of waste	PERFWASTE	0.146						
On-time and vendor performance	PERFVEND	0.081						
Compensation: quality and throughput	COMPQLTY	0.187						
Compensation: variances and budgets	COMPBGT	−0.096						
Compensation: non-financial measures	COMPNF	−0.048						
Employees understand company strategy	STRPLAN	−0.163	−2.535	0.012				
Empowerment in decision making	EMPOWER	0.159	2.457	0.015				
Overall					Adj $R^2 = 0.439$		13.827	0.000

[a] $n = 253$. All F statistics are for the change in the step model, except for the overall F.

The results here show that there is a strong relationship between firms that use these measures and JIT. The results also indicate that firms employing higher levels of JIT practices more frequently measure and report quality results to their employees, providing further evidence of the ties between TQM and JIT. Although it is not possible to discern from this study whether these non-traditional performance measures were a part of the JIT-implementation change process, the results demonstrate the importance for firms practicing JIT to have appropriate measures in place to assess JIT effectiveness.

Table 8
Regression results for the relationship between performance measures and incentives and quality JIT practices (dependent variable = JITQLTY)[a]

Independent variables		Beta	t	Sig.	R^2	ΔR^2	F	Sig. F
Step 1					0.088	0.088	6.741	0.000
Organizational structure of firm	STRUCTR	0.072	1.080	0.282				
Firm's innovation strategy	INNOV	0.175	2.642	0.009				
Size of firm measured by sales	SIZE	0.203	3.031	0.003				
Step 2					0.288	0.200	11.509	0.000
Organizational structure of firm	STRUCTR	0.030						
Firm's innovation strategy	INNOV	0.054						
Size of firm measured by sales	SIZE	0.079						
Frequency quality results reported	QLTYREV	0.139	2.013	0.045				
Use of bottom-up measures	BOTTOM	0.324	4.684	0.000				
Use of benchmarking techniques	BENCH	0.007	0.101	0.920				
Performance measures of waste	PERFWASTE	0.043	0.600	0.549				
On-time and vendor performance	PERFVEND	0.169	2.546	0.012				
Step 3					0.332	0.044	4.420	0.005
Organizational structure of firm	STRUCTR	0.042						
Firm's innovation strategy	INNOV	0.053						
Size of firm measured by sales	SIZE	0.060						
Frequency quality results reported	QLTYREV	0.113						
Use of bottom-up measures	BOTTOM	0.256						
Use of benchmarking techniques	BENCH	−0.015						
Performance measures of waste	PERFWASTE	0.004						
On-time and vendor performance	PERFVEND	0.137						
Compensation: quality and throughput	COMPQLTY	0.207	2.745	0.007				
Compensation: variances and budgets	COMPBGT	−0.077	−1.081	0.281				
Compensation: non-financial measures	COMPNF	−0.013	−0.188	0.851				
Step 4					0.335	0.004	0.573	0.565
Organizational structure of firm	STRUCTR	0.030						
Firm's innovation strategy	INNOV	0.055						
Size of firm measured by sales	SIZE	0.060						
Frequency quality results reported	QLTYREV	0.129						
Use of bottom-up measures	BOTTOM	0.254						
Use of benchmarking techniques	BENCH	−0.025						
Performance measures of waste	PERFWASTE	0.004						
On-time and vendor performance	PERFVEND	0.140						
Compensation: quality and throughput	COMPQLTY	0.196						
Compensation: variances and budgets	COMPBGT	−0.094						
Compensation: non-financial measures	COMPNF	−0.005						
Employees understand company strategy	STRPLAN	−0.071	−0.987	0.325				
Empowerment in decision making	EMPOWER	0.055	0.756	0.451				
Overall					Adj $R^2 = 0.292$		7.766	0.000

[a] $n = 253$. All F statistics are for the change in the step model, except for the overall F.

Managers who are most committed to JIT appear to be most concerned that vendors deliver high quality products in a timely fashion. As buffer stock is removed in a JIT environment, the reliability of vendors becomes critical to success.

A significant relationship exists between firms that have adopted a higher level of JIT manufacturing practices and the use of manufacturing performance measures related to scrap, rework, machine downtime, and setups. These performance measures appear to be more important for

Table 9
Regression results for the relationship between performance measures and incentives and uniquely JIT practices (dependent variable = JITUNIQUE)[a]

Independent variables		Beta	t	Sig.	R^2	ΔR^2	F	Sig. F
Step 1					0.124	0.124	9.874	0.000
Organizational structure of firm	STRUCTR	0.136	2.072	0.039				
Firm's innovation strategy	INNOV	0.159	2.454	0.015				
Size of firm measured by sales	SIZE	0.248	3.788	0.000				
Step 2					0.246	0.123	6.663	0.000
Organizational structure of firm	STRUCTR	0.117						
Firm's innovation strategy	INNOV	0.066						
Size of firm measured by sales	SIZE	0.177						
Frequency quality results reported	QLTYREV	0.118	1.664	0.098				
Use of bottom-up measures	BOTTOM	0.278	3.903	0.000				
Use of benchmarking techniques	BENCH	0.067	0.915	0.362				
Performance measures of waste	PERFWASTE	−0.111	−1.515	0.131				
On-time and vendor performance	PERFVEND	0.102	1.505	0.134				
Step 3					0.266	0.020	1.851	0.139
Organizational structure of firm	STRUCTR	0.108						
Firm's innovation strategy	INNOV	0.065						
Size of firm measured by sales	SIZE	0.152						
Frequency quality results reported	QLTYREV	0.102						
Use of bottom-up measures	BOTTOM	0.223						
Use of benchmarking techniques	BENCH	0.070						
Performance measures of waste	PERFWASTE	−0.124						
On-time and vendor performance	PERFVEND	0.134						
Compensation: quality and throughput	COMPQLTY	0.035	0.422	0.659				
Compensation: variances and budgets	COMPBGT	−0.048	−0.634	0.527				
Compensation: non-financial measures	COMPNF	0.123	1.758	0.080				
Step 4					0.299	0.033	4.645	0.011
Organizational structure of firm	STRUCTR	0.074						
Firm's innovation strategy	INNOV	0.070						
Size of firm measured by sales	SIZE	0.151						
Frequency quality results reported	QLTYREV	0.151						
Use of bottom-up measures	BOTTOM	0.222						
Use of benchmarking techniques	BENCH	0.044						
Performance measures of waste	PERFWASTE	−0.123						
On-time and vendor performance	PERFVEND	0.096						
Compensation: quality and throughput	COMPQLTY	0.005						
Compensation: variances and budgets	COMPBGT	−0.096						
Compensation: non-financial measures	COMPNF	0.145						
Employees understand company strategy	STRPLAN	−0.215	−2.902	0.004				
Empowerment in decision making	EMPOWER	0.146	1.956	0.052				
Overall					Adj $R^2 = 0.253$		6.558	0.000

[a] $n = 253$. All F statistics are for the change in the step model, except for the overall F.

evaluation and control of more narrowly defined advanced manufacturing practices than the broader perspective of JIT as a comprehensive organizational strategy. These results can be compared to those of Daniel and Reitsperger (1996), which found that US JIT firms did not modify their MAS to include the monitoring of these non-financial manufacturing measures to the same extent as did their Japanese counterparts that had more JIT strategies in place.

Table 10
Regression results for the relationship between performance measures and incentives and JIT practices (dependent variable = JITIMP)[a]

Independent variables		Beta	t	Sig.	R^2	ΔR^2	F	Sig. F
Step 1					0.189	0.189	16.264	0.000
Organizational structure of firm	STRUCTR	0.128	2.040	0.043				
Firm's innovation strategy	INNOV	0.249	3.993	0.000				
Size of firm measured by sales	SIZE	0.291	4.612	0.000				
Step 2					0.452	0.263	19.660	0.000
Organizational structure of firm	STRUCTR	0.080						
Firm's innovation strategy	INNOV	0.109						
Size of firm measured by sales	SIZE	0.149						
Frequency quality results reported	QLTYREV	0.209	3.444	0.001				
Use of bottom-up measures	BOTTOM	0.345	5.685	0.000				
Use of benchmarking techniques	BENCH	0.039	0.626	0.532				
Performance measures of waste	PERFWASTE	0.037	0.585	0.559				
On-time and vendor performance	PERFVEND	0.155	2.675	0.008				
Step 3					0.491	0.040	5.265	0.002
Organizational structure of firm	STRUCTR	0.087						
Firm's innovation strategy	INNOV	0.108						
Size of firm measured by sales	SIZE	0.127						
Frequency quality results reported	QLTYREV	0.183						
Use of bottom-up measures	BOTTOM	0.273						
Use of benchmarking techniques	BENCH	0.022						
Performance measures of waste	PERFWASTE	−0.001						
On-time and vendor performance	PERFVEND	0.124						
Compensation: quality and throughput	COMPQLTY	0.181	2.746	0.007				
Compensation: variances and budgets	COMPBGT	−0.074	−1.177	0.240				
Compensation: non-financial measures	COMPNF	0.028	0.485	0.628				
Step 4					0.520	0.029	5.988	0.003
Organizational structure of firm	STRUCTR	0.052						
Firm's innovation strategy	INNOV	0.112						
Size of firm measured by sales	SIZE	0.127						
Frequency quality results reported	QLTYREV	0.227						
Use of bottom-up measures	BOTTOM	0.266						
Use of benchmarking techniques	BENCH	−0.003						
Performance measures of waste	PERFWASTE	0.000						
On-time and vendor performance	PERFVEND	0.131						
Compensation: quality and throughput	COMPQLTY	0.151						
Compensation: variances and budgets	COMPBGT	−0.120						
Compensation: non-financial measures	COMPNF	0.049						
Employees understand company strategy	STRPLAN	−0.194	−3.168	0.002				
Empowerment in decision making	EMPOWER	0.153	2.485	0.014				
Overall					Adj $R^2 = 0.489$		16.670	0.000

[a] $n = 253$. All F statistics are for the change in the step model, except for the overall F. JITIMP is the total averages of the three JIT factors shown in Table 2.

5.2. Hypothesis 1B

Supporting hypothesis 1B, the results indicate that firms more committed to JIT are more likely to tie compensation rewards to non-traditional performance measures. This study lends additional support to Dean and Snell (1996) and the argument that compensation incentives are given to encourage team-oriented, quality work in JIT-oriented firms.

No significant relationship between the degree of JIT practices used and compensation rewards for compliance with budgets and variances exists, supporting earlier research by Abernethy and Lillis (1995) and Perera et al. (1997). As noted by Perera et al. (1997, p. 569), "changes in manufacturing strategies to emphasise quality, flexibility, dependability and low cost should be accompanied by changes in formal performance measurement systems to place greater emphasis on non-financial (operations-based) measures."

5.3. Hypothesis 1C

Partial support for hypothesis 1C exists. The addition of employee empowerment and strategic understanding to the regressions is significant in all but the JITQLTY model. While both explanatory variables in this step show a significant contribution, the employee understanding of the firm's overall strategic plan (STRPLAN) has an unexpected negative relationship to the degree of JIT implemented.

The research results suggest that empowerment in decision making is not necessarily related to an understanding of corporate strategies. In this sense, these results support Ittner and Larcker's (1998) conclusion that recent initiatives to link long-term strategies to short-term actions have yet to prove successful. Epstein and Birchard (2000, p. 10) explain that managers always have had trouble making the system for corporate strategy, business-unit strategy, budgeting, performance evaluation, and compensation work as one. Kalagnanam and Lindsay (1998, p. 28) note that there is little current evidence of the successful use of "strategically-driven performance measurements." One plausible explanation is that management believes that operating decisions made by knowledgeable and adequately trained employees will translate automatically to the accomplishment of tasks congruent with organizational and JIT objectives. Alternatively, employee empowerment might contain the same limitations of previous participation initiatives. As noted by Macintosh (1994, p. 246), "*real* empowerment, as opposed to only *pseudo* empowerment, means putting employees on an equal power footing with managers and shareholders. This would more than likely require not only the reversal of organization goals..., but also some kind of overturning of the current power structures of today's organizations."

5.4. Control variables

Two of the control variables, size and innovation, are significantly related to JIT implementation in all of the regression models. As expected, larger firms that view themselves as leaders in innovation employ more JIT techniques. A larger firm likely would have more resources to study the ramifications of JIT and to make the necessary changes for its adoption. Leaders in product technology and design are less resistant to change, and are more likely to be leaders in manufacturing technology. A linkage also exists between the overall JIT model and a more decentralized organizational structure. Greater independence allows a firm to be more flexible and adaptive to operational advancements. These results are similar to those reported by Abernethy and Lillis (1995) and Perera et al. (1997) in their studies of flexible manufacturing strategies.

6. Summary

An increasingly competitive marketplace places more pressure on an organization's ability to create value. To build and strengthen long-term competitive advantage, firms must provide low-cost, high-quality products under time-based demands. The JIT production system, whether it is referred to as lean or world-class manufacturing, is one strategic tool that enables firms to achieve these objectives. The results of this study demonstrate that successful implementation of JIT practices also requires a complementary decision-making and control system. Specifically, firms need a decision-making system that incorporates bottom-up measures, and frequent reports of quality results and vendor reliability. Firms also must adapt their control system by empowering workers and linking compensation rewards to quality results.

Specific research limitations might reduce the generalizability and applicability of the findings. As in all survey research, a necessary assumption in data collection is that the respondents had sufficient knowledge to answer the items and that they answered the questions conscientiously and truthfully. Respondents might have been unfamiliar with questionnaire terms used to describe JIT methods, and reluctant to take the necessary time to examine the attached glossary explaining the JIT terminology. Second, an important element of this survey instrument is capturing the degree of JIT implementation. Although the 11 JIT indicators on the survey were supported through a thorough study of JIT literature, they might not have been indicative of actual company practices. Finally, the majority of the sample firms were selected through a random process; however, the approach to JIT sample firm identification was not random. The diversion from completely random sample selection might make the test sample non-representative of other US manufacturing firms.

JIT is expected to become an even more effective production strategy with the expansion of e-business and the Internet that facilitate adjustments to demand shifts (Piszczalski, 2000; Sowinski & Orton, 2001). Further research is needed to determine the extent to which firms *change* their internal performance measurement and incentive systems subsequent to JIT adoption and what role management accountants play in the change process. In light of criticisms of cost accounting methods, the evaluation of the MAS in a JIT environment should include specific accounting practices for product and inventory costing. A missing research link is the effect of world-class manufacturing practices and performance measures, either individually or in combination, on long-term organizational profitability. For change to occur in either manufacturing practices or performance measurement, managers must believe that the new systems contribute to sustained profitability.

Despite the noted limitations, this research contributes to our understanding of the links between strategy and management accounting practices and techniques. The results indicate that the MAS employed by firms adopting JIT as an organizational strategy emphasizes a non-traditional performance measurement and incentive system that supports JIT's continuous improvement goals. The research also underscores that management accounting must be strategically driven to meet the complex information requirements of advanced manufacturing environments.

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Appendix A. Survey questions measuring performance measures and incentive systems

QLTYREV[a]
How frequently do top management, middle management, and first-line supervisors receive information on:
Quality results attained?
Business consequences of quality?

COMPQLTY[b]
How important are these performance measures in determining compensation for middle management and for first-line supervisors:
Product quality?
Throughput time?
Team performance?

BOTTOM[c]
How often are the following techniques used to evaluate information:
Cause-and-effect diagrams?
Histograms?
Flowcharting?
Pareto analysis?
Scatter diagrams?
Statistical process control charts?

COMPBDGT[b]
How important are these performance measures in determining compensation for middle management and for first-line supervisors:
Variance analysis?
Conformance to budget?

BENCH[c]
How often are the following techniques used to evaluate information:
Benchmarking of operating methods?
Benchmarking of products or services?
Benchmarking of delivery systems?

PERFWASTE[b]
How important are the following performance measures in evaluating your manufacturing system:
Equipment downtime?
Scrap?
Rework?
Setup times?

STRPLAN[d]
How well is your firm's strategic plan understood:
By middle managers?
By first-line managers?
By non-management personnel?

PERFVEND[b]
How important are the following performance measures in evaluating your manufacturing system:
On-time delivery?
Vendor performance in product quality?
Vendor performance in on-time delivery?

COMPNF[b]
How important are non-financial performance measures in determining compensation for middle management and for first-line supervisors?

EMPOWER[d]
How much are line managers and non-management personnel empowered to make decisions?

[a] Possible responses: Never = 1; Annually = 2; Quarterly = 3; Monthly = 4; Weekly = 5; Daily = 6; Continuously = 7.
[b] Possible responses: Not at all = 1; Little = 2; Some = 3; Considerable = 4; and Extreme = 5.
[c] Possible responses: Never = 1; Rarely = 2; Occasionally = 3; Frequently = 4; Regularly = 5.
[d] Possible responses: Not at all = 1; Little = 2; Partially = 3; Considerably = 4; Fully = 5.

Appendix B. Survey items measuring JIT implementation factors and control variables

JITMANUF[a]
Indicate the extent to which your firm has implemented the following techniques:
Focused factory.
Group technology.
Action plan to reduce setup times.
Total productive maintenance.
Multi-function employees.
Uniform work load.

JITQLTY[a]
Indicate the extent to which your firm has implemented the following techniques:
Product quality improvement.
Process quality improvement.

JITUNIQUE[a]
Indicate the extent to which your firm has implemented the following techniques:
Kanban system.
JIT purchasing.

INNOV[b]
What most closely matches your firm's strategy related to innovation in:
Product technology?
Process design?
Product design?

STRUCTR[c]
What is the organizational structure of your firm's:
Overall company?
Individual operations?
Individual departments?

[a] Possible responses: No intention = 1; Considering = 2; Beginning = 3; Partially = 4; Substantially = 5; Fully = 6.
[b] Possible responses: Follower = 1...2...3...4...5 = Leader.
[c] Possible responses: Highly Centralized = 1...2...3...4...5 = Highly Decentralized.

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