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**Effect of Total Quality Management and Just-In-Time practices on Competitive Performance
- Empirical Evidence**

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Abstract

This paper presents results of an empirical analysis of TQM and JIT practices and their impacts on competitive performance in manufacturing plants. This study explores the mutual supportive relationship between TQM and JIT practices, which lead to a synergy effect on competitive performance in manufacturing plants. Ten measurement scales were constructed to describe TQM and JIT. The impacts of TQM and JIT practices on competitive performance indexes in term of quality, cost, delivery, and flexibility were tested by regression analysis. The study concludes that simultaneous implementation of TQM and JIT practices will result in significantly higher competitive performance level than implementation of practices from only one of TQM or JIT. The findings support the integrated approach of joint implementation of TQM and JIT to attain excellent quality, cost, delivery, and flexibility, which will help manufacturing firm to improve the competitive position.

Keywords: TQM, JIT, Competitive Performance, Manufacturing, Empirical Research

1. Introduction

In recent years, there are interests of study about implementation of Just-in-time (JIT) and total quality management (TQM) for business improvement. There are many manufacturing organization implement JIT and TQM principles in several difference ways. Some of manufacturing plant may choose to start with TQM practices in order to improve quality of product and service through the organization. Some of plants may choose to start with implementation of JIT practices for eliminating waste and maximizing utilization of manufacturing resources. The separate impacts of JIT and TQM practices on business performance were analyzed and discussed in many empirical studies (e.g. Saraph et al. 1989, Flynn et al., 1994; Ahire et al., 1996; McLachlin, 1997; Sakakibara et al., 1997; 1999, Kaynat, 1998, Matsui, 2002b, Ahmad, 2003,). In 1990s, some studies tried to explore the joint effect of both implementation of JIT and TQM on manufacturing performance (e.g. Flynn et al., 1995; Vuppapapati et al., 1995, Sriparavastu and Gupta, 1997, Cua et al. 2001). Those studies pointed out the empirical evident that joint implementation of JIT and TQM resulted in

significant higher performance than implementation of either one. In this study, the authors continue to examine the relationship between implementation of JIT and TQM practices and competitive performance in one hundred sixty-three manufacturing plants from three industries: electrical & electronic, machinery, and automobile in five countries: United States, Japan, Germany, Italia, and Korea. This study focuses on the synergy of joint implementation of TQM and JIT practices upon competitive performance in manufacturing plants. The next section of this paper reviews the literature about TQM, JIT, and competitive performance. A simple analytical framework is introduced in the third section. Data collection is described in the fourth section. Measurement analysis is presented in the fifth section. The relationships between implementation of TQM and JIT and competitive performance are examined by regression analysis, which is presented in section sixth. Finally, implications and conclusion are discussed at the last sections.

2.Literature Review

This section summaries the relationship between TQM, JIT, and competitive performance in recent empirical studies. Quality management represents company-wide activities to improve the quality level of products and works through customer orientation, continuous quality improvement, employees' involvement, etc. to establish and sustain a competitive advantage (Flynn et al., 1995, Matsui, 2002). Much has been written about how quality should be measured, controlled and improved. In early stages of empirical research in quality management, Saraph et al. (1989) pioneered the effort to identify an empirical validate TQM constructs primary using the quality prescriptions of quality guru. They described quality management by such measures like management leadership, role of quality department, training, product/service design, supplier quality management, process management, quality data and reporting, employee relation. Flynn et al. (1995), used practitioner's and empirical literatures developed the quality management framework for manufacturing companies, including top management support, workforce management, quality information, supplier involvement, product design, process management, and customer involvement. Ahire et al. (1996), based on both conceptual literature and empirical and practitioner literature, developed the instrument for

quality management, using top management commitment, supplier quality management, supplier quality management, supplier performance, customer focus, SPC usage, benchmarking, internal quality information usage. Recently, much of effort is to empirically examine the impact of quality management practice on quality performance and competitive advantages (Kaynat, 1998; Matsui, 2002).

JIT describes the idea of producing the necessary items in the necessary quantities at the necessary time, and eliminating all sources of waste in operations. JIT production is an approach that seeks to eliminate all source waste in production activities by providing the right part at the right place at the right time. JIT production system was developed by Toyota Motor Corporation in Japan during the 1970s. It became popular in the early 1980s with the advocator of Toyota Production System (TPS), who was Taiichi Ohno, a former vice president at Toyota. TPS was then transferred to the US and other countries, and became a powerful tool for improving the effectiveness of production systems. Since 1980s JIT production has been one of the hottest research areas in operations management. Many researchers have investigated the development of JIT implementation together with its impact on organizational performances. Sakakibara et al. (1993) developed an analytical framework and measurement instrument for JIT based on sixteen key JIT practices. Calen et al. (2000) suggested that JIT manufacturing at the plant level is associated with greater productivity in inventory usage, lower total and variable costs, but not fixed costs, and higher profits. Ahmad et al., (2004) examined the role of infrastructure practices in the effectiveness of JIT practices from three perspectives—universal, contingency, and configurationally, and reported that synergy between JIT practices and infrastructure practices needs to be exploited to attain superior plant competitiveness.

The relationship between TQM and JIT was examined in some empirical studies (Flynn et al., 1995; Sriparavastu and Gupta, 1997; Cua et al., 2001). These studies reported the compatibility and trade-off between TQM and JIT practices and their combination yields synergies that lead to higher level of performance. Flynn et al., (1995) found the significant impact of TQM and JIT on quality and JIT performances. Sriparavastu and Gupta, (1997) reported that most production systems can benefit from

certain aspects of JIT implementation without having TQM in place first. Cua et al., (2001) pointed out the evidence supporting the compatibility of the TQM and JIT practices and that manufacturing performance is associated with the level of implementation of both socially- and technically-oriented practices of the these programs.

Table 1: Summary of literature on TQM and JIT implementation

Techniques and practices	Empirical study on TQM and JIT implementation													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Customer involvement		x	x	x		x								x
Supplier quality involvement	x	x	x	x	x	x	x	x	x	x	x		x	x
Cleanliness and organization		x				x		x					x	
Process control	x	x	x	x	x	x			x	x				x
Information feedback	x	x	x	x	x	x							x	x
JIT schedule								x	x		x	x	x	x
JIT layout							x	x	x		x	x		x
JIT delivery by supplier							x	x	x			x	x	x
Setup Time reduction							x	x	x	x	x	x	x	x
Pull System							x	x	x	x	x	x	x	x

References: (1) Saraph et al., 1989; (2) Flynn et al., 1994; (3) Powell, 1995; (4) Ahire et al., 1996; (5) Kaynat, 1998; (6) Matsui, 2002; (7) Mehra and Inman, 1992; (8) Sakakibara et al., 1993; (9) McLachlin, 1997; (10) Ahmad et al., 1999, (11) Callen et al., 2000; (12) Ahmad et al., 2004, (13) Flynn et al., 1995; (14) Cua et al., 2001

Summary of literature of empirical studies about TQM and JIT is presented in Table 1. Summary of first six empirical studies about TQM (Saraph et al., 1989; Flynn et al., 1994; Powell, 1995; Ahire et al., 1996; Kaynat, 1998; Matsui, 2002 b) leads to identification of five practices that commonly cited as core TQM practices. These are cleanliness and organization, customer involvement, process control, feedback, and supplier quality involvement. Next, summary of six empirical studies about JIT (Mehra and Inman, 1992; Sakakibara et al., 1993; McLachlin, 1997; Ahmad et al., 1999, Callen et al., 2000; Ahmad et al., 2004) leads to

identification of five practices that commonly cited as core JIT production practices: setup time reduction, JIT schedule, JIT layout, JIT delivery by suppliers, pull system. Finally, summary of the last two empirical studies (Flynn et al., 1995; Cua et al., 2001) presents the common TQM and JIT practices that can be considered for integrated implementation.

3. Analytical Framework

The objective of this study is to analysis the impact of implementation of TQM and JIT on competitive performance of the manufacturing plants. The main issue relates with compatibility between TQM and JIT practices and the synergy of simultaneous implementation of TQM and JIT which discussed in above cited literature (Vuppalapati et al., 1995 ; Flynn et al., 1995; Spriparavastu and Gupta, 1997, Cua et al., 2001). Since TQM and JIT have common objectives of improving efficiency of production through elimination of waste and continuous improvement, their interaction results in a higher competitive position of manufacturing organization. The research question is “Does the concurrent implementation of TQM and JIT practices result in better competitive performance than single implementation either one?”. In this exploratory study, the impact of TQM and JIT is examined at the plant level because the authors believe that plant level is best environment for implementing and integrating a set of TQM and JIT practices. The framework of this study is described in the Figure 1. JIT and TQM described by five common JIT practices (JIT schedule, JIT layout, JIT delivery by supplier, pull system, setup time reduction), and five common TQM practices (cleanliness and organization, customer involvement, process control, information feedback, supplier quality involvement) that found as core practices of JIT and quality management from cited above literature. Competitive performance is summarized as quality, cost, dependability, flexibility as suggested in literature (Flynn et al., 1994; Cua et al., 2001; Matsui, 2002b; Ahmad, 2003).

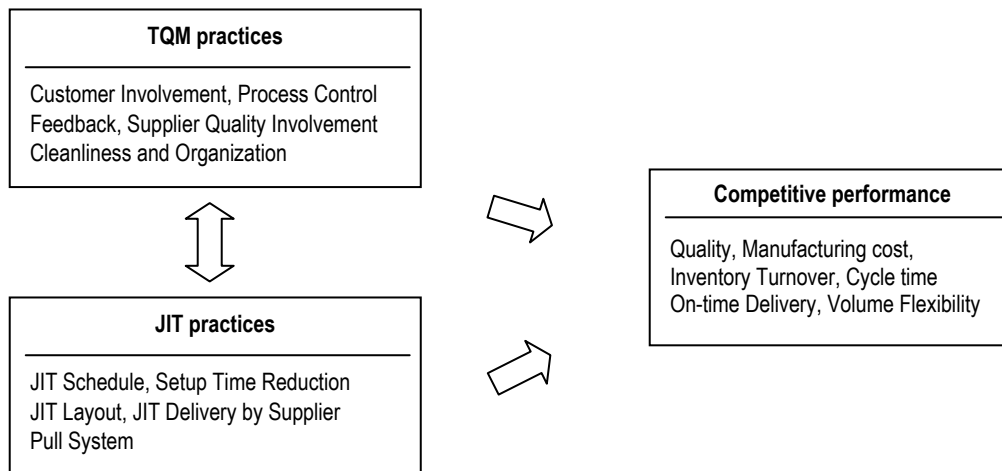


Figure 1: Research framework

To measure different dimensions of TQM and JIT in production, ten measurement scales and two super scales were constructed. Five scales that summarized as bellows evaluate five dimensions of TQM.

- Customer involvement (CIVM): This scale assesses the level of customer contact, customer orientation, and customer responsiveness
- Supplier quality involvement (SQIV): This scale assesses the amount and type of interaction, which occurs with vendors regarding quality concerns
- Cleanliness and organization (CO3S): This scale evaluates whether plant management has taken steps to organize and maintain the work place in order to help employees accomplish their jobs faster and instill a sense of pride in their work place
- Process control (PCTL): This scale measure the use of statistical process control in production and in office support function, in designing ways to “fool proof” process and self inspection
- Information feedback (IFFB): This scale measures whether the plant provides shop-floor personnel with information regarding their performance (include quality and productivity) in a timely and useful manner.
- A TQM super scale is constructed from above five scales

Next, five measure are constructed to describer JIT production activities as follows:

- JIT schedule (JSCD) assesses whether there is time for meeting each day's schedule including catching up after stoppages for quality considerations or machine breakdown
- JIT layout (JLYT) measures use of manufacturing cells, elimination of forklifts and long conveyers, and use of smaller equipment designed for flexible floor layout, which are all associated with JIT manufacturing
- Just-in-time delivery by suppliers (JDSP): measures whether vendors have been integrated into production in terms of using kanban containers, making frequent or JIT delivery and quality certification
- Pull system (PULS): measures whether or not the plant has implemented the physical elements of a kanban/pull system
- Setup time reduction (STRD) evaluates whether the plant is taking measures to reduce setup times and in order to facilitate JIT production
- A JIT supper scale is constructed from above five JIT scales

This study uses the key competitive measures suggested by Flynn et al. (1995), Schroeder and Flynn (2001), and Matsui (2002b), summarized in six indexes as follows:

- Cost: Unit cost of manufacturing (UCMF), Inventory turnover (INTO), and Cycle time (CLTE)
- Quality: Conformance to product specification (CFPS)
- Dependability: On time delivery (OTDV)
- Flexibility: Volume flexibility (VLFX)

Then, the authors propose four hypotheses on the impact of single effect and joint effect of implementation of TQM and JIT upon competitive performances in manufacturing plants. The first hypothesis concerns with impact of single implementation of TQM on competitive performance.

H 1: TQM practices significantly impact on competitive performance

The second hypothesis concerns with impact of single implementation of JIT on competitive performance.

H 2: JIT practices significantly impact on competitive performance

The third and fourth hypotheses concern with impact of simultaneous implementation of TQM and JIT on competitive performance.

H 3: Simultaneous implementation of TQM and JIT practices will scientifically result in higher competitive performance than implementation of practices from only TQM

H 4: Simultaneous implementation of JIT and TQM practices will result in higher competitive performance than implementation of practices from only JIT

The first step analysis is to test the measurement for reliability and validity. Next, reliable and valid data is used to test the hypothesis that mentioned above. The hypotheses are tested by using regression models, which use independent variables are TQM and JIT super scales, and dependent variables are competitive performance indexes that discussed in previous section.

4.Data Collection

Data used for the subsequent analyses were gathered through an on-going international joint research on High Performance Manufacturing project started in 1980s. Some of significant results of this project are shown in Flynn et al, (1995); Schroeder and Flynn, (2001); Cua et al., 2001; Matsui (2001, 2002a, 2002b) concerning with some important aspects of manufacturing plants: quality, JIT production, information systems and information technologies, technology development, manufacturing strategy, improvement and performance. In this research, the authors acquired the data from survey using intensive questionnaire in one hundred and sixty-three manufacturing plants in five countries: the United States, Japan, Germany, Italia, and South Korea during 2003-2004. The respondents are belonging to three industries: electrical & electronic, machinery, and automobile. The information about implementation of TQM and JIT practices were evaluated by six individuals in several positions from manager to direct labors. Direct labors, quality manager, supervisors answered the question about cleanliness and organization, customer involvement. Question items concern with information feedback and process control, were assessed by direct labor, quality manager and production engineer.

Inventory manager, quality manager, and direct labor evaluated supplier quality involvement. All the questionnaires about JIT practices: JIT schedule, JIT layout, JIT delivery by supplier, setup time reduction, pull system were answered by three individuals: inventory manager, production controller, and supervisor. The above TQM and JIT practices measurement scales are constructed by four to eight question items evaluated on a seven-point Likert scale (1=Strongly disagree, 4=Neither agree nor disagree, 7=Strongly agree). Individual question items are shown in the appendix. Finally, six competitive performance indexes were subjectively judged by plant manager. Each plant manager was asked to indicate his/her opinion about how the plant compares to its competitors in the industry on a global basis on a five-point Likert scale (1=Poor or low end of the industry, 2=Below average, 3=Average, 4= Equivalent to competitor, 5=Superior or top of the industry).

Table 2: Demographic of survey's respondent

Industry	US	Japan	Germany	Italia	South Korea	Total
Electrical & Electronic	9	10	9	10	10	48
Machinery	11	12	13	10	10	56
Automobile	9	13	19	7	11	59
Total	29	35	41	27	31	163

Table 3: Results of measurement testing

Variables	Alpha	Eigen value	Mean	Std	JSCD	JLYT	JDSP	PULS	STRD	JIT	CSIV	CO3S	IFFB	PCTL	SQIV	TQM	CFPS	UCMF	INTO	ONDV	VLFX	CLTE
	.771	2.727	4.944	.7047	.484	.534	.395	.633	.780	.328	.474	.482	.448	.433	.763	.242	.311	.238	.282	.219	.200	
	.757	2.805	5.046	.6835	1	.517	.424	.433	.737	.408	.512	.488	.409	.430	.736	.178	.124	.210	.313	.423	.249	
	.692	2.256	4.538	.7054	1	.522	.540	.805	.742	.131	.174	.346	.338	.400	.737	.176	.258	.229	.293	.266	.177	
	.792	2.463	3.872	.9537	1	.364	1	.364	.742	.131	.174	.346	.262	.278	.625	.101	.100	.151	.281	.133	.168	
	.730	2.438	4.854	.6974	1	.757	1	.757	.229	.229	.391	.517	.421	.375	.731	.278	.362	.212	.229	.202	.207	
	.753	2.585	4.653	.5723	1	1	1	1	.346	.346	.482	.603	.490	.504	.937	.249	.284	.265	.368	.311	.258	
	.782	2.314	5.224	.4737	1	1	1	1	1	1	.440	.507	.510	.619	.561	.127	.121	.199	.333	.356	.032	
	.795	2.817	5.362	.6178	1	1	1	1	.462	.462	1	.462	.455	.452	.633	.273	.222	.169	.293	.423	.101	
	.796	2.792	4.839	.8566	1	1	1	1	1	1	.742	.742	.742	.627	.764	.172	.279	.180	.263	.230	.100	
	.822	2.952	4.803	.7943	1	1	1	1	1	1	1	1	1	.594	.681	.225	.291	.171	.338	.262	.166	
	.783	3.124	4.955	.5055	1	1	1	1	1	1	1	1	1	1	.670	.140	.193	.121	.290	.202	.019	
	.818	2.937	5.130	.4796	1	1	1	1	1	1	1	1	1	1	.878	.296	.301	.239	.420	.406	.156	
			3.872	.6829	1	1	1	1	1	1	1	1	1	1	1	1	.230	.220	.423	.301	.297	
			3.315	.8611	1	1	1	1	1	1	1	1	1	1	1	1	1	.385	.292	.218	.357	
			3.455	.8659	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.329	.266	.615	
			3.851	.8521	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.463	.361	
			3.926	.7477	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.320	
			3.821	.6521	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	

Note:

Correlations are boldface type show significant relationship between variables

Correlations greater than .165 are significant at the .05 level

Correlations greater than .220 are significant at the .01 level

5.Measurement Analysis

The reliability and validity analysis was performed to evaluate the measurement properties of the individual items and constructs. Reliability is an estimate of measurement consistency. In this research, Cronbach's alpha coefficient is calculated for each scale to evaluate the reliability. The Table 3 shows alpha values for all scales exceeded the minimum acceptable alpha value of 0.6 for data gathered from one hundred and sixty-three plants. Most the scales have alpha value above 0.75; indicate that the scales were internally consistent. Next, the validity of measurement scales is tested against content and construct.

Content validity: An extensive review of literature and empirical researches was undertaken about quality management practices, production management and organization performance to ensure content validity. This research follows the works of Flynn et al. (1994); Schroeder and Flynn, (2001); Cua et al., 2001; and Matsui (2002b) and who developed and tested a set of measurement scales of quality management and JIT in the framework of High Performance Manufacturing Project.

Construct validity: Construct validity was conducted to ensure that all question items in a scale all measure the same construct. Within scale factor analysis was tested with the three criteria: uni-dimensionality, a minimum eigenvalue of 1, and item factor loadings in excess of 0.4. The results of measure testing shows in Table 3 present that all scale had good construct validity. All of scales have eigenvalue are more than two. Factor loading for each items are more than 0.4, mostly ranged between 0.7 and 0.9 as shown in Appendix. The statistical relationships within research variables are tested by conducting simple correlation analysis. The results show the significant correlation within TQM variables and within JIT variables. Every TQM and JIT variables were found significantly relates each others (except the correlation between two variables: customer involvement and JIT layout). This result reflexes the mutual supportive relationship between TQM and JIT practices because they have similar objectives.

Next, the authors examined correlation relationship between individual TQM and JIT practices and competitive performance indexes. It is found that different variables correlate each other in different ways. JIT

schedule, JIT delivery by suppliers, setup time reduction, cleanliness and organization, process control, and information feedback significantly correlates with all of six performance measures relating quality, cost, delivery, and flexibility. Among six competitive performance measures, on-time delivery performance is found that significantly correlate with all TQM and JIT practices. The supper scales of TQM and JIT are found significantly correlate with all competitive performance measures. The result of correlation analysis is presented in the Table 3.

6. Regression Analysis on Effects Of TQM And JIT Practices On Competitive Performance

The hypotheses on impact of implementation TQM and JIT on competitive performance were tested by regression analysis. Independent variables are TQM supper scale and JIT supper scale. Dependent variables are six competitive performance indexes: quality conformance, manufacturing cost, inventory turnover, in-time delivery, volume flexibility, and cycle time. In testing hypothesis, a regression model was constructed hierarchically for each dependent variable. Firstly, the authors tested for Hypothesis H1 and H3. Regression model was started with only independent variable is TQM. This model was used for testing hypothesis H1. Next, JIT variable was added for testing hypothesizes H 3. The similar method was utilized for testing hypothesizes H 2 and H 4. The results of hierarchy regression analysis are presented as follows.

Conformance to product specification as dependent variable

Firstly, the authors started the model with TQM as independent variable. Regression result is shown in the Table 4a. TQM was found significantly impact on quality conformance. TQM variable explain eight percent of variability of quality conformance. The addition of JIT variable to the model led to a very slight, nonsignificant increase in R^2 value showing that parallel implementations of TQM and JIT not significantly result in higher quality performance comparing with implementation of only TQM. Next, other hierarchy regression model starting with JIT variable was examined and results are shown in the Table 4b. The fist model shows significant impact of JIT on quality conformance. JIT variable explains six percent of variability of quality conformance. The addition of TQM variable to the model produced a statistically significant increase in R^2

value indicating that simultaneous implementation of TQM and JIT result in significant higher quality performance comparing with implementation of only JIT.

Table 4a: Impact of TQM and JIT on quality performance

Model	R	R ²	Adjusted R ²	F	Sig.	Change Statistics			df	Constant	Independent variables	
						R ² Change	F Change	Significant F change			TQM	JIT
1	.296	.088	.082	14.058	.000	.088	14.058	.000	147	1.679	.296**	
2	.305	.093	.080	7.427	.001	.005	.813	.369	146	1.619	.234*	.095

Table 4b: Impact of JIT and TQM on quality performance

Model	R	R ²	Adjusted R ²	F	Sig.	Change Statistics			df	Constant	Independent variables	
						R ² Change	F Change	Significant F change			TQM	JIT
1	.249	.062	.056	9.664	.002	.062	9.664	.002	147	2.498		.249**
2	.305	.093	.080	7.427	.001	.031	4.929	.028	146	1.619	.234*	.095

Unit cost of manufacturing as dependent variable

Applying the same method as previous section, the authors examine impact of TQM and JIT on unit cost of manufacturing. TQM explains for nine percent of variability of unit cost of manufacturing. JIT explains for eight percent of variability of unit cost of manufacturing. However, it was found joint implementation of TQM and JIT not result in a significant higher level of unit cost of manufacturing.

Table 5a: Impact of TQM and JIT on unit cost of manufacturing

Model	R	R ²	Adjusted R ²	F	Sig.	Change Statistics			df	Constant	Independent variables	
						R ² Change	F Change	Significant F change			TQM	JIT
1	.301	.091	.084	14.343	.000	.091	14.343	.000	145	.524	.301**	
2	.321	.103	.091	8.229	.000	.013	2.013	.158	144	.410	.201	.151

Table 5b: Impact of JIT and TQM on unit cost of manufacturing

Model	R	R ²	Adjusted R ²	F	Sig.	Change Statistics			df	Constant	Independent variables	
						R ² Change	F Change	Significant F change			TQM	JIT
1	.284	.081	.074	12.648	.001	.081	12.648	.001	145	1.346		.284**
2	.321	.103	.091	8.229	.000	.022	3.583	.060	144	.410	.201	.151

Inventory Turnover as dependent variable

Starting the first model with TQM as only independent variable, the authors found significant relationship between TQM and inventory turnover. TQM accounts for five percent of variability of inventory turnover. Additional JIT variable to the model produced a statistically significant increase in R² value indicating that simultaneous implementation of TQM and JIT result in significant higher quality performance comparing with implementation of TQM. Next, start the model with JIT as independent variable. It was found that JIT significantly explains seven percent of variability of inventory turnover. The addition of TQM variable to the model led to a very slight, nonsignificant increase in R² value showing that join implementation of JIT and TQM not significantly result in higher inventory turnover comparing with implementation of only JIT.

Table 6a: Impact of TQM and JIT on inventory turnover

Model	R	R ²	Adjusted R ²	F	Sig.	Change Statistics			df	Constant	Independent variables	
						R ² Change	F Change	Significant F change			TQM	JIT
1	.239	.057	.050	8.655	.004	.057	8.655	.004	145	1.232	.239**	
2	.278	.077	.064	5.956	.003	.020	3.129	.079	144	1.080	.113	.190

Table 6b: Impact of JIT and TQM on inventory turnover

Model	R	R ²	Adjusted R ²	F	Sig.	Change Statistics			df	Constant	Independent variables	
						R ² Change	F Change	Significant F change			TQM	JIT
1	.265	.070	.064	10.810	.001	.070	10.810	.001	145	1.608		.265**
2	.278	.077	.064	5.956	.003	.007	1.095	.297	144	1.080	.113	.190

Cycle time as independent variable

TQM not significantly impact on cycle time. Additional JIT to the model produced a statistically significant increase in R² value indicating that simultaneous implementation of JIT and TQM result in significant higher on-time delivery comparing with implementation of only TQM. JIT significantly account for six percent of variability of cycle time. The addition of TQM variable to the model led to a very slight, nonsignificant increase in R² value, showing that join implementation of JIT and TQM not significantly result in improvement of cycle

time comparing with implementation of only JIT

Table 7a: Impact of TQM and JIT on cycle time

Model	R	R ²	Adjusted R ²	F	Sig.	Change Statistics			df	Constant	Independent variables	
						R ² Change	F Change	Significant F change			TQM	JIT
1	.156	.024	.017	3.556	.061	.024	3.556	.061	144	2.300	.156	
2	.258	.067	.054	5.081	.007	.043	6.469	.012	144	2.131	-.029	.277**

Table 7b: Impact of JIT and TQM on cycle time

Model	R	R ²	Adjusted R ²	F	Sig.	Change Statistics			df	Constant	Independent variables	
						R ² Change	F Change	Significant F change			TQM	JIT
1	.258	.066	.060	10.157	.002	.066	10.157	.002	144	2.017		.258**
2	.258	.067	.054	5.081	.007	.000	.070	.791	144	2.131	-.029	.277**

On-time Delivery as dependent variable

TQM accounts for seven-teen percent of variability of on-time delivery. Additional JIT variable to the model led to a very slight, nonsignificant increase in R² value showing that join implementation of JIT and TQM not significantly result in higher on-time delivery comparing with implementation of only TQM. JIT explain third-teen percent of variability of on-time delivery. Additional TQM to the model produced a statistically significant increase in R² value indicating that simultaneous implementation of JIT and TQM result in significant higher on-time delivery comparing with implementation of only JIT.

Table 8a: Impact of TQM and JIT on on-time delivery

Model	R	R ²	Adjusted R ²	F	Sig.	Change Statistics			df	Constant	Independent variables	
						R ² Change	F Change	Significant F change			TQM	JIT
1	.420	.176	.171	31.245	.000	.176	31.245	.000	147	-.024	.420**	
2	.437	.191	.180	17.122	.000	.015	2.647	.106	146	-.151	.313**	.162

Table 8b: Impact of JIT and TQM on on-time delivery

Model	R	R ²	Adjusted R ²	F	Sig.	Change Statistics			df	Constant	Independent variables	
						R ² Change	F Change	Significant F change			TQM	JIT
1	.368	.136	.130	22.920	.000	.136	22.920	.000	147	1.318		.368**
2	.437	.191	.180	17.122	.000	.055	9.923	.002	146	-.151	.313**	.162

Volume flexibility as dependent variable

TQM significantly accounts for sixteen percent of variability of volume flexibility. JIT significantly account nine percent of variability of volume flexibility. Regression results shown in the Table 8a and 8b indicate that either starting with TQM or starting by JIT, joint implementation of TQM and JIT significantly improve volume flexibility.

Table 9a: Impact of TQM and JIT on volume flexibility

Model	R	R ²	Adjusted R ²	F	Sig.	Change Statistics			df	Constant	Independent variables	
						R ² change	F Change	Significant F change			TQM	JIT
1	.406	.165	.159	28.788	.000	.165	28.788	.000	147	.638	.406**	
2	.410	.168	.157	14.645	.000	.003	.584	.446	146	.585	.355**	.077

Table 9b: Impact of JIT and TQM on volume flexibility

Model	R	R ²	Adjusted R ²	F	Sig.	Change Statistics			df	Constant	Independent variables	
						R ² Change	F Change	Significant F change			TQM	JIT
1	.311	.097	.091	15.666	.000	.097	15.666	.000	147	2.047		.311**
2	.410	.168	.157	14.645	.000	.071	12.401	.001	146	.585	.355**	.077

The above results prove Hypothesizes H1 and, H2 that TQM and JIT alone significantly impact on competitive performance. In addition, Hypothesis 3 and 4 were proved showing that; in term of conformance quality, inventory turnover, on-time delivery; volume flexibility, and cycle time; joint implementation of TQM and JIT results a better performance than implementation of practices from only TQM or JIT.

7. Implications and Discussion

In the previous sections, the authors presented a result of empirical study about impact of concurrent implementation of TQM and JIT on competitive performance. The authors proposed a simple analytical framework for studying TQM, JIT, and competitive performance in manufacturing company. Four hypotheses on impacts of TQM and JIT on competitive performance were established. Then, based on literature, we proposed ten measurement scales concerning TQM and JIT and all of ten measurement scales: JIT schedule, JIT layout, JIT delivery by supplier, pull system, setup time reduction, cleanliness and organization, customer

involvement, process control, information feedback, and supplier quality involvement, are satisfactory in terms of reliability and validity for the data set of one hundred sixty-three manufacturing plants in five countries. Using these scales, the authors examined the joint effect of TQM and JIT practices upon competitive performance. The main conclusions we derive from a series of statistical analyses are summarized as below.

- TQM significantly impacts on conformance quality, unit cost of manufacturing, inventory turnover, on-time delivery; volume flexibility.
- JIT significantly impacts on conformance quality, unit cost of manufacturing, inventory turnover, on-time delivery; volume flexibility, and cycle time.

There are significant differences from adopting only JIT or only TQM or both programs simultaneously for a continuous improvement of competitive position of manufacturing companies.

- The manufacturing plants implement both TQM and JIT have significant increased competitive performance level in cycle time, and inventory turnover when compared to manufacturing plants implement only TQM practices.
- The manufacturing plants implement both TQM and JIT have significant increased competitive performance level in conformance quality, on-time delivery, and volume flexibility when compared to manufacturing plants implement only JIT practices.
- In term of unit cost of manufacturing, there is no significant difference between manufacturing plants implement both TQM and JIT, and manufacturing plants implement only TQM or JIT.
- For the manufacturing plant already started improvement program with implementation of JIT practices, additional implementation of TQM practices leads to the significantly improvement of conformance quality, on-time delivery, and volume flexibility.
- For the manufacturing plant already started improvement program with implementation of TQM practices,

additional implementation of JIT practices leads to the significantly improvement of cycle time and inventory turnover.

The positive impact of both TQM and JIT on competitive performance; in term of quality cost, delivery, and flexibility,; can be explained as follows:

- TQM practices basically improve manufacturing performance by reducing process variance. Using statistical process control and providing feedback information to shop floor operators might help the plant to identify and eliminate all of source of process variance. Beside of these, keeping the workstation clean, tidy and well organized creates a basic foundation for any quality improvement activities. Establishing long-term relationships with suppliers and actively engage suppliers in plant's quality improvement efforts will result a higher incoming quality. Closer contact with customers, actively involve customers in product design process will help the plant to meet customer's requirement and expectation, also improve customer's responsiveness. The elimination of process variance leads to higher quality conformance, reducing cost and improving performance delivery.
- JIT practices improve manufacturing performance by reducing level of inventory and production cycle time. Utilization of the pull system with the philosophy "produce the necessary items in the necessary quantities at the necessary time" allows the plants reduce the work-in-process and final product's inventory. Frequent deliveries by supplier make the plant to reduce incoming material inventory. Reduction of cycle time can be obtained by reducing setup time and handling/moving time. In fact, setup time can be reduced done by converting most of setup time to external time, while the machine is running. Handling and moving time can be reduced by locating machines to support JIT production flow or laid out the shop floor so that processes and machines are in close proximity to each other. Reduction of inventory and cycle time leads to lower manufacturing cost, improve on-time delivery and flexibility to change production volume.

- The synergy between TQM and JIT can be explained by the fact that there is the mutual supportive relationship between TQM and JIT practices. The result of simple correlation analysis reveals the significant relationship among ten individual TQM and JIT practices that examined in this study (except correlation between customer involvement and pull system). Since having the same common objectives, TQM and JIT practices support each other and depend on each other.
- As discussed in cited literatures, TQM practices are primary determinants for quality performance such as quality conformance; JIT practices are primary determinants for JIT performance such as inventory turnover, and volume flexibility. This study found the statistical evidence of significant impact of TQM on JIT performance and significant impact of JIT on quality performances. TQM can contribute on JIT performance in two ways: by reducing the inventory and by shortening production cycle time. Minimization of process variance results a reduction of defected products, thus, reduce the need for safety stock buffer. The reduction of defected product also leads to a reduction of time delay for rework, inspection, and time for machine stop. These allow the production run faster with shorter consuming time from material receiving to customer delivery. In the other side, JIT contributes to quality performance by mainly inventory reduction. Since the need for safety inventory buffer is reduced, number of part, component, work in process, and final product is minimized. Consequently, potential damage during handling and spoilage during extended storage period is reduced, thus, the manufacturing process variation is reduced.

8.Limitation and future research

One of the limitations of this study is utilizing gathered data from not very large number of manufacturing plants. The expansion of survey population might help to find out more useful information appropriate conclusion. Further research for more comprehensive structure of manufacturing performance is supposed to be necessary and fruitful. Path analysis modeling techniques can be used to assess direct and indirect effect of each TQM and JIT practices and its infrastructure on competitive performance. We should conduct similar

analyses concerning the requirement of TQM and JIT regarding its interaction with other management system such as human resource, manufacturing strategy, etc. Another possibility is a comparative analysis of TQM and JIT, using data set of US, European and Japanese manufacturing companies.

9. Conclusion

This article presents an analysis of effect of joint implementation of TQM and JIT on competitive performance. This study explores the mutual supportive relationship between TQM and JIT practices, which lead to a synergy effect on competitive performance in manufacturing plants. The study concludes that simultaneous implementation of TQM and JIT practices resulted in significantly higher competitive performance level than implementation of practices from only one of TQM or JIT. The findings support the integrated approach of implementation of TQM and JIT to attain excellent quality, cost, delivery, and flexibility, which will help manufacturing firm to improve the competitive position.

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Appendix: Question items of quality management scales

(Value inside bracket show factor loading for each question item)

Cleanliness and Organization

1. Our plant emphasizes putting all tools and fixtures in their place (.69)
2. We take pride in keeping our plant neat and clean (.85)
3. Our plant is kept clean at all times (.86)
4. Employees often have trouble finding the tools they need (.57)
5. Our plant is disorganized and dirty (.79)

Feedback

1. Charts showing defect rates are posted on the shop floor (.71)
2. Charts showing schedule compliance are posted on the shop floor (.71)
3. Charts plotting the frequency of machine breakdowns are posted on the shop floor (.68)
4. Information on quality performance is readily available to employees (.81)
5. Information on productivity is readily available to employees (.76)

Process Control

1. Processes in our plant are designed to be "foolproof." (.75)
2. A large percent of the processes on the shop floor are currently under statistical quality control (.84)
3. We make extensive use of statistical techniques to reduce variance in processes (.81)
4. We use charts to determine whether our manufacturing processes are in control (.70)
5. We monitor our processes using statistical process control (.87)

Customer Involvement

1. We frequently are in close contact with our customers (.69)
2. Our customers seldom visit our plant (removed)
3. Our customers give us feedback on our quality and delivery performance (.70)
4. Our customers are actively involved in our product design process (.58).
5. We strive to be highly responsive to our customers' needs (.72)
6. We regularly survey our customers' needs (.71)

Supplier Quality Involvement

1. We strive to establish long-term relationships with suppliers (.64)
2. Our suppliers are actively involved in our new product development process (.72)
3. Quality is our number one criterion in selecting suppliers (.55)
4. We use mostly suppliers that we have certified (.61)
5. We maintain close communication with suppliers about quality considerations and design changes (.80)
6. We actively engage suppliers in our quality improvement efforts (.77)
7. We would select a quality supplier over one with a lower price (removed)

Setup Time Reduction

1. We are aggressively working to lower setup times in our plant (.712)
2. We have converted most of our setup time to external time, while the machine is running (.599)
3. We have low setup times of equipment in our plant (removed)
4. Our crews practice setups, in order to reduce the time required (.784)
5. Our workers are trained to reduce setup time (.807)
6. Our setup times seem hopelessly long. (.554)

Pull system

1. Suppliers fill our kanban containers, rather than filling purchase orders (.755)
2. Our suppliers deliver to us in kanban containers, without the use of separate packaging (.760)
3. We use a kanban pull system for production control (.806)
4. We use kanban squares, containers or signals for production control (.815)

Equipment Layout

1. We have laid out the shop floor so that processes and machines are in close proximity to each other (.732)
2. We have organized our plant floor into manufacturing cells (.569)
3. Our machines are grouped according to the product family to which they are dedicated (.507)
4. The layout of our shop floor facilitates low inventories and fast throughput (.789)
5. We have located our machines to support JIT production flow (.792)
6. We have located our machines to support JIT production flow (.662)

Just-in-Time Delivery by Suppliers

1. Our suppliers deliver to us on a just-in-time basis (.763)
2. We receive daily shipments from most suppliers (.690)
3. We can depend upon on-time delivery from our suppliers (.737)
4. Our suppliers are linked with us by a pull system (.615)
5. Suppliers frequently deliver materials to us (.525)

Daily Schedule Adherence

1. We usually meet the production schedule each day (.817)

2. Our daily schedule is reasonable to complete on time (.647)
3. We usually complete our daily schedule as planned (.827)
4. We build time into our daily schedule to allow for machine breakdowns and unexpected production stoppages (removed)
5. We build extra slack into our daily schedule, to allow for catching up (removed)
6. We cannot adhere to our schedule on a daily basis (.632)
7. It seems like we are always behind schedule (.746)

JIT supper scale

- Setup Time Reduction (.753)
- Pull system (.626)
- JIT Layout (.727)
- Just-in-Time Delivery by Suppliers (.767)
- JIT schedule (.713)

TQM supper scale

- Cleanliness and Organization (.696)
- Feedback (.777)
- Process Control (.800)
- Customer Involvement (.745)
- Supplier Quality Involvement (.898)

Competitive performance

- Unit cost of manufacturing
- Inventory turnover
- Cycle time
- Conformance to product specification
- On time delivery
- Volume flexibility