

## Relationships among TQM, TPM and JIT and Performance

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**Abstract:** In order to investigate the relationships among TPM (Total Productive Maintenance), TQM (Total Quality Management) and JIT (Just-in-Time), as well as the impact of implementation JIT on the company's performance, this study builds up the conceptual model based on literature review and conducts a survey of 118 manufacturing companies in the Pearl River Delta region of China by questionnaires. It shows that (1) there is a strong relationship between TPM and TQM. Both TPM and TQM effects on JIT directly; (2) JIT can improve operational performance; (3) JIT impacts the financial performance through operational performance. Hence, the Chinese manufacturing enterprises may improve performance through JIT, before which, they can implement TQM and TPM first, to achieve higher performance.

**Keywords:** TQM, TPM, JIT, operational performance

### I. Introduction

Because of the rising of operating costs, the decline of the demand due to financial crisis, industrial upgrading, energy-saving, and environmental protection requirements and a series of internal and external business environment changes, Chinese manufacturing industry is facing fierce challenges. China's manufacturing enterprises continuously introduce advanced production technology from abroad to improve competitiveness, such as: total quality management (TQM), total productive maintenance (TPM), just-in-time (JIT). TPM helps to maximize equipment effectiveness throughout its lifecycle, and TQM is aimed at continuously improving and sustaining the product quality and workflow [1]. JIT provides manufacturing with flexibility and speed essential to win the global competition [2].

Imai(1998) indicates that TQM and TPM are strongly interrelated. McKone et al. (2001) demonstrates TPM positive direct to TQM and JIT. Cua et al.(2001) believes that TQM, TPM, JIT interaction between each other[3][4][1]. Liu Shilan (2006) discusses what is the system requirement before introduction TQM and puts forward an organizational change model in the view of TQM[5], Qi Ershi (1997) analyzed the problems which Chinese manufacturing enterprises met when implementing Toyota Production in recent years[6]. Wang Hui-Fang (2000) surveyed 16 companies, and summarized the JIT's implementation and

application [7]. In China, many research about TQM, TPM, JIT are theoretical discussion and case studies [5][6][7][8][9] and empirical study is little. However, most of the studies on TQM, JIT, and TPM investigate these programs separately [1]. The research of relationship among TQM, TPM, JIT did not have consistent conclusion. So it is necessary for the sample of Chinese manufacturing enterprises to explore the relationship between TQM, TPM and JIT.

In the field of international manufacturing operations, there have some research between JIT and performance. But the relationship between JIT and operational performance, JIT and financial performance didn't have the same results. Flynn et al.(1995), Sakakibara et al.(1997), Dean and Snell(1996) researches shown JIT not have the direct effect on the operational performance[10][11][12], but Kim and Takeda(1996), Nakamura et al.(1998) insist there has the direct between them[13][14]. Inman and Mehra (1993) found JIT have the direct effect on the financial performance [15]; but Balakrishnan et al. (1996) compared the company JIT and NON-JIT found no different between financial performances [16]. Although the researches only consider the relationship between JIT and operational performance, JIT and financial performance, not consider the indirect effect on financial through operational performance.

Dose the implementation of TPM and TQM really improve JIT? And JIT really improves the company's performance? In order to answer these questions, this paper conducts an empirical study and establishes the theoretical model of TQM, TPM, JIT and performance. The sample of this study involves 118 companies in the Pearl River Delta region of China. Our study is expected to provide useful guidance in for Chinese enterprises whether implement JIT TQM and TPM or not.

### II. Theoretical Foundation and Research Hypotheses

#### The relationship between TPM, TQM and JIT

JIT is the genesis of time-based competition that "provides manufacturing with flexibility and speed essential to meet global competition" [17]. Mehra and Inman(1992) proposed that JIT was both a vendor strategy and a production strategy"...that strives to achieve excellence in manufacturing by reducing setup times ... through the use of group technology, cross-training of employees, and sound

preventive maintenance”[18].

TQM is a manufacturing program aimed at continuously improving and sustaining quality products and processes by capitalizing on the involvement of management, workforce, suppliers, and customers, in order to meet or exceed customer expectations [19]. Product’s quality need to start from the source. Through supply chain relationship management and establish a good partnership with supplier, it can ensure smooth production and the quality of finished goods. TQM can improve the quality of products, reduce product failure rates and rework rates, making the production site stable and orderly production, thereby supporting the orderly production system.

TPM is designed to maximize equipment effectiveness (improve overall efficiency) by establishing a comprehensive productive-maintenance system covering the entire life of the equipment, spanning all equipment-related fields [20]. We use maintenance and maintenance equipments to ensure its “fixed rate”, then support the JIT. We improve the company’s technology base through improve equipment technology and employees’ skills. The improved of employees’ skills, so that they can solve unexpected problems. K.E. McKone found that the TPM improves the JIT through provide reliable and effective maintenance of equipment and facilities [4].

TQM and TPM are the two pillars that support JIT production systems, but it is often hard to clearly separate their effect on manufacturing performance, which indicates that perhaps TQM and TPM are strongly interrelated [3]. This is reflected in the following hypotheses.

*H1a: TQM has a positive relationship with JIT*

*H1b: TPM has a positive relationship with JIT*

*H1c: TQM and TPM are strongly interrelated*

### JIT effects on the firm performance

JIT is a system of production control that seeks to minimize raw materials and WIP inventories; control defects; stabilize production; continuously simplify the production process; and create a flexible, multi-skilled work force [21]. Shorter setup times reduce the time required to change machines to work on different parts and also allow for smaller lot sizes. With lot sizes decreased, inventory levels are lowered, production flexibility is increased, and faster feedback on quality is obtained. We use “Kanban” to achieve the JIT, and then to meet the customer demand. The more rapid detection of problems leads to better quality, with less scrap and rework [22]. This is reflected in the following hypothesis.

*H2a: JIT has a positive effect on the operational performance*

JIT is expected to improve firm performance flow of small lot sizes integrating schedule stability, product quality, short setup times and so on[23]. Moreover, these production improvements are assumed to bring direct financial savings. In theory, JIT improves profitability due to its impact on the two interdependent components of ROA and return on sales (ROS). JIT is expected to improve ROA in several ways.

First, asset turnover should increase, as JIT frees up assets and capital. Second, lower inventory levels reduce the asset base, improving asset turnover in the short term. Third, fewer buffer inventories motivate the elimination of non-value-added activities (such as dealing with defects and stock-outs) that have a negative impact on the profit margin [24]. Balakrishnan et al.(1996) indicates that these effects are not necessarily set up in the short term, for example, companies need to invest the cost of capital to learn just in time production and investment of these funds will reduce the corporate profit margins, but will bring long-term business profit [16]. This is reflected in the following hypothesis.

*H2b: JIT has a positive effect on the financial performance*

### The relationship between operational performance and financial performance

Production companies showed good operating performance, the low cost and good quality assurance, will give companies an edge when receiving orders to lower prices and quality assurance for more orders, which can increase their sales and profits. Flexible production lines, shorter delivery allows companies to better meet customer order requirements, improve customer satisfaction; expand its influence in the industry. It can also deal with the uncertainty of customer demand, and meet the urgent orders for more profitable enterprises. Manufacturing operations which can improve performance enhance enterprise competitiveness brought to expand its market share, increase sales and profits. This is reflected in the following hypothesis.

*H3: Operational performance has a positive effect on the financial performance*

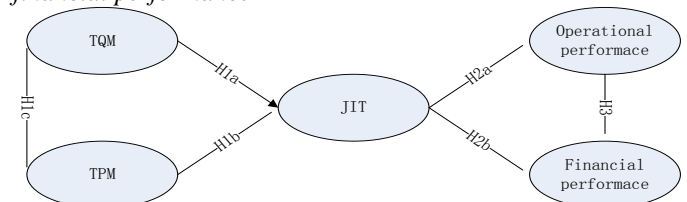


Figure 1 The theoretical model diagram

## III. Research Method

### Sample and data collection

Prior to the collection of data, approximately a dozen business managers from Pearl River Delta region of China were personally interviewed to help determine whether differences in perceptions about this paper’s variables could be discerned and whether items of the questionnaire could be understood easily. The individuals selected represented a diversity of industries and a range of managerial hierarchy. Based on numerous opened discussions, we concluded that it would be appropriate to sample subjects in upper to high organizational levels across different industries.

Data collection consisted of a random sample from Pearl

River Delta region of China. About a total 500 enterprises were drawn from the sampling frame which consisted of enterprises from Guangzhou, Dongguan, Foshan, Jiangmen, Zhongshan etc. A total response of 143 questionnaires were recovered, 25 respondents did not complete answer. There are 118 valid questionnaires.

### Measures

The measure of JIT was adapted from Cua et al.(2001),R.R. Fullerton & C.S. McWatters(2001),Shah and Word(2003)[1][2][25]. JIT is operated as a second-order construct with three dimensions (pull system production, equipment layout, JIT delivery by suppliers).

The measure of TQM was adapted from Cua et al.(2001),Shah & Word(2003)[1][25], TQM is operated as a second-order construct with three dimensions ( supply relationship management, quality improvement, customer involvement).

The measure of TPM was adapted from Cua et al.(2001), K. E. Mckone et al.(2001), Shah & Word(2003)[1][4][25], TPM is operated as a second-order construct with three dimensions (autonomous & planned maintenance, 5S, visual management).

Table 1 The results of the second-order CFA

Variable	second-order	cronbach's $\alpha$ & Correlation coefficient	Explained by factors	index of second-order CFA
JIT	pull system production	0.618**	62%	$\chi^2/df=1.259$ ,GFI=0.967, CFI=0.991,TLI=0.991, RMR=0.045,RMSEA=0.047, IFI=0.991,PNFI=0.503
	equipment layout	0.836	45%	
	JIT delivery by suppliers	0.445**	64%	
TQM	supply relationship management	0.392**	40%	$\chi^2/df=1.877$ ,GFI=0.957, CFI=0.963,TLI=0.929, RMR=0.065,RMSEA=0.087, IFI=0.964,PNFI=0.485
	quality improvement	0.827	62%	
	customer involvement	0.545**	55%	
TPM	autonomous & planned maintenance	0.847	68%	$\chi^2/df=2.645$ ,GFI=0.928, CFI=0.948,TLI=0.914, RMR=0.045,RMSEA=0.119, IFI=0.949,PNFI=0.559
	5S	0.868	69%	
	visual management	0.611**	62%	

Note: \*\* indicates correlation significant at the 0.01 level.

## IV. Research Results and Discussion

### Test the theoretical model

We use structural equation model to analysis these variables affect each other, see Figure 1. Overall model fit: this index is used to test the fit of the overall model and the observed data, the measuring criteria of which have many indices. Hair et al. (1998) considered there are three types of it [26].Absolute fit measures:  $\chi^2/df=1.675$ , RMSEA=0.076, RMR=0.106, GFI=0.865. It is obvious that  $\chi^2/df$  and RMSEA are both acceptable and RMR was a little bigger, GFI litter smaller than 0.9. Incremental fit measures: IFI=0.926, TLI=0.907, CFI=0.924. It is obvious that IFI, TLI, CFI are both acceptable while GFI is lower than 0.9. Parsimonious fit measures: PNFI=0.681. As a whole the

Organization performance can be understood from different points of view and influenced by various levels of analysis. The measure of operational and financial performance in this paper refers to the study of Cua et al.,(2001),K.E. Mckone et al.,(2001),Shah & Word(2003)[1][4][25].

### Reliability and validity of the data

This study validates the reliability of variables used Cronbach's  $\alpha$  coefficient, the variables that TQM, JIT, TPM, operational performance, financial performance Cronbach's  $\alpha$  are 0.827、0.778、0.868、0.787、0.884.

All the items in the questionnaire used in this paper come from literatures which have been published, and many scholars have used these items to scale correlative variables. So we can believe that there are enough reliabilities and availabilities for the items. This paper has consulted many experts in correlative field, and carried out experimentation among managers of enterprises. Finally, this paper corrected some items of questionnaire according to the advice of experts and top managers. So the questionnaire is of much validity. Table 1 shows the results of the second-order CFA.

overall model fit of the theory model in this paper is acceptable according to the judge of every index.

### Test of hypothesis

The results of this study's hypotheses were shown in table 2. The hypothesis H1a, H1b, H1c, H2a, and H3 were supported by the data, the corresponding path coefficients significant level; hypothesis H2b is not supported, the corresponding path coefficients have not yet reached significant levels.

Table 2 Theoretical model of the path coefficients and hypothesis testing

The relationship between variables	Path coefficient	P	hypot hesis	Test results
TQM---->JIT	0.418***	0.000	H1a	support
TPM---->JIT	0.300**	0.008	H1b	support
TQM<--->TPM	0.334**	0.007	H1c	support

JIT---->operation al performance	0.263*	0.027	H2a	support
JIT---->financial performance	0.066	0.557	H2b	not support
operational performance-----> financial performance	0.370**	0.001	H3	support

Note: standardized path coefficient; \*\*\* indicated p <0.001; \*\* indicated p <0.01; \* indicated p <0.05.

Table 3 The indirect path coefficient model

The relationship between variables	Indirect path coefficient
JIT---->financial performance	0.124

V Discussion and Conclusions

According to the results of the analysis we draw the conclusions as following: 1 ) there have a strong relationship between TPM and TQM, and TPM & TQM has direct effects on JIT; 2) JIT has a effect on operational performance; 3) JIT impacts the financial performance through operational performance.

1) There is a strong relationship between TPM and TQM. Both TPM and TQM have direct effects on JIT. For companies who are dedicating to improve competitive advantage by strengthen management. How to implement TPM, TQM and JIT are important issues which China’s enterprises are confronting. The research show that a strong relationship between TPM and TQM, and has direct effects on JIT, the result is consistent with K.E. McKone (2001), Flynn, B. B(1995)[4][10]. For the management practices, the Chinese enterprises can implement the TQM and TPM before JIT.

2) JIT effects on operational performance. Our research has the same result with R.R. Fullerton et al.(2001),K.E. McKone (2001) that JIT implementation can improve firm’s operational performance [2][4]. It shows that the JIT can improve the operational performance in China, can improve such as product quality, flexible and delivery.

3) JIT impacts the financial performance through operational performance. It has some different result with R.R. Fullerton et al.(2003) which think the JIT directly impact the financial performance[27]. We believe that this is not in contradiction with the conclusions, but the expansion of the research. One reason is they didn’t think the operational performance’s indirect effect; another reason is from the difference between China and other country. Most of Chinese enterprises are not good at operational management, so their operational performance would be improved first after implementing JIT. And the enhance of finance performance needs a relatively long time. Chinese enterprises should not focus on the financial performance overfull at the beginning, but continue to implement JIT.

Although this paper contributes many important conclusions,

there are some limitations. Because the sample of this paper was mainly from enterprises in Pearl River Delta region of China and the results have not been confirmed in other regions, we will do some comparative study in the future. A variety of future research studies are possible including longitudinal studies and more detailed examination of the relationship among the three programs.

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