An empirical investigation on the relationship between TPM TQM and production performance of manufacturing industry

Ran Hong Cui* · Chang Eun Kim*
*Dept. of Industrial & System Engineering, Myongji University

제조 공장의 TPM 및 TQM과 생산 운영 사이의 관계에 대한 연구

최 연 홍* · 김 창 은*
*명지대학교 산업시스템공학과

Abstract

공장의 생산력을 향상하기 위하여, 현재 많은 공장에서는 동시에 TPM & TQM을 진행하고 있다. 이러한 활동을 통하여 제품의 품질을 향상하고, 원가를 절감하고, 납기를 단축하며, 생산의 유연성을 확보한다.

본 논문은 한국의 제조업에 대한 설문조사를 통하여 TPM 및 TQM과 생산 실행 요인 사이의 관계를 분석함으로써, 적극적으로 제조업에서 생산력을 향상하고 촉진할 수 있는 요인을 얻는 것이다.

Keywords : TQM, Production Performance, TPM, Manufacturing Industry

1. Introduction and Theoretical Background

In today's global economy, the survival of companies depends on their ability to rapidly innovate and improve. As a result, an increasing search is on for methods and processes that drive improvements in quality, costs and productivity. Successful implementation of TPM and TQM is found to improve manufacturing performance and help companies gain a competitive edge.

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. In contemporary management, TQM has become the major business strategy in 1990s(Witcher, 1994; Lee and Leung,1999).

Table 1 provides a comparative analysis of these empirical studies. Through a judgmental process of grouping similar requirements, an integrated TQM can be viewed as a composite of eight constructs as "employee empowerment, training and education, top management leadership, customer focus, communication to improve quality, quality management, employee involvement and process improvement".

Seiichi Nakajima, vice-chairman of the Japanese Institute of Plant Engineers JIPE., the predecessor of the Japan Insti-tute of Plant Maintenance JIPM., promoted TPM throughout Japan and has become known as the father of TPM. In 1971, TPM was defined by JIPM as: TPM is designed to maximize equipment effectiveness improving overall efficiency by establishing a comprehensive productive maintenance system covering the entire life of the equipment, spanning all equipment-related fields planning, use,

2007년 5월 접수; 2007년 6월 수정본 접수; 2007년 6월 게재확정

<Table 1>Summary of critical factors of TQM

	Factors for TQM implementation
Saraph et al. 1989	1.top management leadership 2.role of the quality department 3.training 4.product design 5.supplier quality management 6.process management 7.quality data reporting 8.employee relations
Flynn et al. 1994	1.product design 2.process management 3.quality information 4.supplier involvement 5.customer involvement 6.top management support 7.work force management
Powell 1995	1.Flexible manufacturing 2.zero defect mentality 3.process improvement 4.measurement 5.closer supplier relationships 6.closer customer relationships 7.committed leadership 8.adoption and communication of TQM 9.open organization 10.employee empowerment 11.benchmarking
Ahire et al. 1996	1.design quality management 2.SPC usage 3.internal quality information usage 4.supplier quality management 5.customer focus 6.top management commitment 7.employee training 8.employee involvement 9.employee empowerment 10.benchmarking
Tamimi 1998	1.top management commitment 2.supervisory leadership 3.education 4.cross functional communications to improve quality 5.supplier management 6.quality training 7.product/service innovation 8.providing assurance to employees
Samon and Terziovski 1999	1.process management 2.information and analysis 3.customer focus 4.leadership 5.strategic planning 6.people management

maintenance, etc. and, with the participation of all employees from top management down to shop-floor workers, to promote productive maintenance through motivation management or voluntary small group activities (Tsuchiya, 1992). From following previous studies in <Table 2>, we can know that the factors that most researchers studied were focused on "autonomous maintenance, planned maintenance, preventive maintenance, operator involvement, training, equipment design and improvement and committed leadership".

<Table 2>Summary of critical factors of TPM

	Factors for TPM implementation
Nakajima 1988	1.autonomous maintenance 2.scheduled maintenance 3.eliminate six big losses to improve equipment effectiveness 4.initial equipment management 5.increased skills of operations& maintenance personnel
Takahashi and Osada 1990	1.5s's self-initiated maintenance 2.planning and management of maintenance 3.improvements in production efficiency and individual improvements 4.equipment technologies 5.quality maintenance 6.human resources development
Tsuchly 1992	1.education for multi-skilling 2.management-by-objectives 3.Five S's and autofocus maintenance 4.planned maintenance 5.maintenance prevention design 6.quality maintenance
Steinbacher and Steinbacher 1993	1.autonomous maintenance 2.preventive maintenance and predictive maintenance 3.corrective maintenance 4.maintenance prevention
Maier et al. 1998	1.operator involvement 2.preventive maintenance 3.teamwork 4.measurement&information availability, work documentation 5.work environment
McKone and Welss 1999	1.autonomous maintenance 2.planned maintenance 3.early equipment design 4.training 5.support group activities, focused improvement teams 6. early product design

TQM is an approach to continuous improvement that involves all levels of an organization(Tammi & Gershon, 1995). It takes elements such as statistical process control and overall "total quality" objective (Benson, 1991).

TQM takes every process in an organization and strives to improve it by using simple quality improvement techniques. TPM is able to define

performance conditions to realize equipment quality and to maintain it so that product quality can be accomplished by equipment. TPM is a very important subset of TQM.

The TPM process increases equipment reliability, makes the process more repeatable, and reduces waste. The key ingredient to the success of a TPM and TQM process is the involvement of the worker. The true power in both TPM and TQM is using the knowledge and experience of all the workers to generate ideas and contribute to the goals and objectives of the company. The goal of TPM is waste reduction and process repeatability. This ties conveniently to the process improvement goals characterized by TQM.

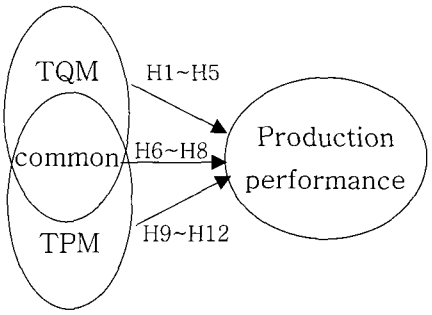
In this research, we are measuring production performance at the plant level. Since the plant does not control sales or costs outside the plant, overall financial measures of production performance are not appropriate. There are many different ways of measuring production performance. The most predominant approach in the literature is to use "cost, quality, delivery, and flexibility" as the four dimensions to exam production performance.

2. Research Methodology and Hypotheses

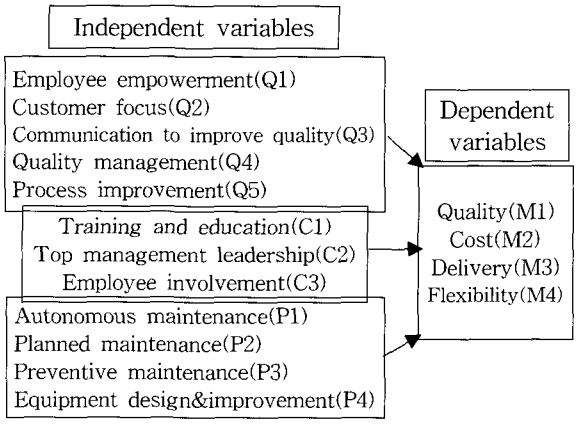
2.1 Data collection methodology

This research sampled manufactures in Korea with simple random sampling method, and a list of 200 names is obtained from Korea National Statistical Office. The survey was conducted by using an e-mail questionnaire. All the contact persons were managers or operators in quality department and maintenance department.

For the items measuring practices and performance, the informations were asked to indicate their agreement or disagreement with statements provided using five-point Likert scale. 3 weeks after this e-mailing, 111 of 430 e-mails were replied, yielding approximately a 12.32% usable response rate after eliminating 29 unusable questionaries.



<Figure 1>Research model



<Figure 2> Factors in research model

2.2 Research hypotheses

Based on the review of the literature on the factors related to the TPM and TQM, the following hypotheses are presented:

H1: Employee empowerment has a positive relationship with production performance.

H2: Customer focus has a positive relationship with production performance.

H3: Communication to improve quality has a positive relationship with production performance.

H4: Quality management has a positive relationship with production performance.

H5: Process improvement has a positive relationship with production performance.

H6: Training and education has a positive relationship with production performance.

H7: Top management leadership has a positive relationship with production performance.

H8: Employee involvement has a positive relationship with production performance.

H9: Autonomous maintenance has a positive relationship with production performance.

H10: Planned maintenanc has a positive relationship with production performance.

H11: Preventive maintenance has a positive relationship with production performance.

H12: Equipment design & improvement has a positive relationship with production performance.

3. Data Analysis and Procedure

The research model was analyzed using SPSS 15.0 program. Data analysis proceeded into reliability analysis, factor analysis and multiple linear regression analysis in this study.

Detailed descriptive statistics relating to the respondents' characteristics are shown in <Table 3>.

<Table 3> The Characteristics of respondents

Category	Items	Frequency	%
Industrial Category	Electric machinery	26	31.7
	Textile industry	24	29.3
	Food industry	15	18.3
	Automobile industry	13	15.9
	Others	4	4.9
Company form	Foreign corporation	16	19.5
	Small & medium enterprise	26	31.7
	large enterprise	40	48.8
Capital volume	Less than 1 billion	19	23.2
	1-50 billion	21	25.6
	Above 51 billion	42	51.2
Employee number	Less than 200	48	58.5
	201-500 persons	21	25.6
	Above 501 persons	13	15.9
Position	Executive manager	26	31.7
	Plant manager	27	32.9
	Engineer	16	19.5
	Others	13	15.9
Years for TQM & TPM	Less than 5 years	29	35.4
	5-10 years	38	46.3
	Above 10 years	15	18.3

<Table 5> Factor analysis results on independent variables

NO.	1	2	3	4	5	6
Q11	0.724					
Q12	0.721					
Q13	0.680					
Q14	0.875					
Q15	0.649					
Q21		0.721				
Q22		0.547				
Q23		0.749				
Q24		0.652				
Q31			0.753			
Q32			0.658			
Q33			0.675			
Q34			0.650			
Q41				0.835		
Q42				0.715		
Q43				0.668		
Q44				0.658		
Q45				0.787		
Q51					0.785	
Q52					0.846	
Q53					0.758	
Q55					0.626	
C11						0.751
C12						0.695
C13						0.810
C14						0.746
C16						0.687

NO.	7	8	9	10	11	12
C21	0.845					
C22	0.685					
C24	0.726					
C25	0.685					
C26	0.785					
C31		0.696				
C32		0.736				
C33		0.685				
C34		0.845				
P11			0.685			
P12			0.785			
P13			0.615			
P14			0.685			
P21				0.785		
P22				0.851		
P23				0.646		
P24				0.659		
P31					0.691	
P32					0.685	
P33					0.785	
P34					0.712	
P41						0.785
P42						0.685
P43						0.675
P44						0.708

3.1 Reliability analysis

In order to ensure that the variables were internally consistent, reliability assessment was carried out using Cronbach's alpha. As <Table 4> shows, all Cronbach's alpha values were greater than 0.7, satisfying a minimum requirement of 0.6 while the variable Q54, C15 and C23 were deleted.

<Table 4> Reliability analysis results of the independent variables

Variable	Cronbach's a	Variable	Cronbach's a
Q1	0.7673	P1	0.7828
Q2	0.7021	P2	0.7560
Q3	0.7157	P3	0.6980
Q4	0.6911	P4	0.7200
Q5	0.7386	M1	0.8471
C1	0.8259	M2	0.6947
C2	0.7005	M3	0.7125
C3	0.7713	M4	0.6852

3.2 Factor analysis

To verify the content validity of measures, factor analysis was performed. The purpose of the factor analysis in this study was to perform the validity and to reduce the independent variables into 12 factors as <Table 5>.

The loading of each variables were greater than 0.6 satisfied the minimum requirement of 0.5.

3.3 Multiple linear regression analysis

Here under are the tests for the predictors' goodness of fit of the regression model and the regression equation.

<Table 6> Output of model testing

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.658	.433	.427	.54358

In the above <Table 6>, the R2 is 0.433. This suggests that there is 43.3% goodness of fit of the model produced by the regression equation.

<Table 7> ANOVA output of hypotheses testing

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	77.34	12	6.44	121.34	.000[a]
	Residual	3.66	69	0.05		
	Total		81			

In <Table 7>, ANOVA tests the hypothesis that there is a linear relationship between the predictors and the dependent variable. F is the ratio of the mean square for regression to the mean square for the residual. In <Table 7>, when all predictors are entered, the significance level associated with the observed value of F is 121.34(≥0.000).

Thus, the hypothesis can be accepted and we may conclude that there is a significant linear relationship between the set of independent variables and the dependent variable.

<Table 8> Regression coefficients analysis

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std.Error	Beta		
1	Constant	3.233	0.219		14.763	0.113
	Q1	0.374	0.026	0.671	14.385	0.00
	Q2	0.286	0.064	0.101	4.469	0.002
	Q3	0.486	0.058	0.212	8.379	0.00
	Q4	0.017	0.072	0.005	0.236	0.217
	Q5	0.263	0.060	0.179	4.383	0.002
	C1	0.317	0.047	0.252	6.748	0.001
	C2	0.192	0.028	0.261	6.845	0.001
	C3	0.447	0.034	0.531	13.144	0.00
	P1	0.364	0.031	0.412	11.757	0.00
	P2	0.421	0.035	0.501	12.029	0.00
	P3	0.501	0.029	0.393	11.133	0.00
	P4	-0.028	0.040	-0.01	-0.700	0.416

a. Dependent Variable: M

4. Conclusions and Limitations

In the multiple linear regression analysis, R2 is 0.433. Thus, there is 43.3% goodness of fit of the model produced by the regression equation.

F-value is 121.34. Thus, the hypothesis can be accepted and we may conclude that there is a significant linear relationship between the set of independent variables and the dependent variable.

So, 'Sig.' (p-value≤0.05) is the significance level for the test of the hypothesis. The 'Sig.' value (p-value≤0.05) for factor Q4 and factor P4 is greater than 0.05(0.217≥0.05, 0.416≥0.05). Therefore, the hypothesis H4 and H12 that there is linear relationship between this predictor and attractiveness can be rejected.

5. Reference

[1] Robin Mann, "Factors affecting the implementation and success of TQM", International Journal of Quality & Reliability Management, Vol.12 No.1 1995,pp 133

[2] K.O. Cua, et al. "Relationships between impleme ntation of TQM, JIT, and TPM and manufacturing performance", Journal of Operations Management, No.19 2001,pp675-694

[3] Ahire,S. et al. "Development and validation of TQM implementation constructs", Decision Sciences, Vol, 27. No.1, 1996, pp.23-56

[4] Zeitz, G. et al. "An employee survey measuring total quality management practices and culture:, Group and Organization Management", Vol, 22 No.4, 1997 pp, 414-44

[5] Powell,T.C,"Total quality management as competitive advantage: a review and empirical study", Strategic Management Study, Vol.16, pp. 15-37

[6] Ahire, S., Golhar, D. and Waller, M. "Development and validation of TQM implementation constructs", Decision Sciences, Vol. 27 No.1,1996, pp23-56

[7] Saraph, J.,Benson, P and Schoroder, R.,"An instrutment for measuring the critical factors of qualtiy management", Decision Seciences, Vol, 20, 1989, pp.810-829

[8] Jiju Antony, Kevin leung and Graeme Knowles,"Critical success factors of TQM implementation in Hong Kong industries", International Journal of Quality & Reliability Management, Vol.19 No.5, 2002,pp. 551-366

[9] Tamimi, N,"A second-order factor ananlysis of critical TQM factors", International Journal of Quality Science, Vol.3 No.1, 1998, pp.71-79

[10] Maier, F.H, Milling, P.M, Hasepusch,J." implementation and outcomes of Total Productive Mantenance. Papers from the 5th International Conferences of the European Operations Managment Association. Thrinity college, University of Dublin, Dublin", Ireland, 1998, pp. 304-309

[11] McKone, K.E, Weiss, E.N. "Total Productive Maintenance: bridging the gap between practice and research", Production and operations Managment 7(4),1999, pp,335-351

[12] Nakajima, S., "Introduction to TPM" Productivity Press, Cambiridge, MA 1998.

[13] Steinbacher, H.R, Stenbacher, N.L "TPM for America: What It Is and Why You Need It." Productivity Press, Cambirdge, MA,1993

[14] Takahashi, Y., Osada, T. "TPM: Total Productive Maintenance", Asia Productivity Organization, Tokyo, Japan,1990

[15] Tsuchiya, S, "Quality Maintenance: Zero Defcts Through Equipment Management", Productivity Press, Cambridge, MA, 1992

[16] 오환종,윤영선,"TPM수행에 영향을 미치는 상황요인에 관한 연구",한국산업경제학회 Vol.13, No.4,2007, pp 33-47

[17] 이진춘,"TQM에서 생산관리 목표와 기업성과와의 관계에서 규모이 영향 분석", 의사결정학연구, Vol.12.No2,2004, pp.45-68

Appendix: Survey Questionnaires

This is a research questionnaire for study on the relationship between TPM and TQM and production performance of manufacturing industry. Your answers will only be used as academic research. Please take your time to answer the questions and make sure you have answer all completely. Thank you.

Best regards

Student: Cui Ranhong
Advisor: Dr. Kim Chang-Eun
Industrial & System Engineering Department, Myongji University

①Strongly disagree ②Disagree ③Average ④Agree ⑤Strongly agree

NO.	Question					
Q11	A more active employee suggestion system	①	②	③	④	⑤
Q12	Ideas from production operators are actively used in production management	①	②	③	④	⑤
Q13	Employee training in problem-solving skills	①	②	③	④	⑤
Q14	All employees protection issues are precatively management	①	②	③	④	⑤
Q15	Database is built for analysis	①	②	③	④	⑤
Q21	Commitments to customers through strengthening of polices, etc	①	②	③	④	⑤
Q22	Comparisons of customer satisfaction with competitors and internal indicators.	①	②	③	④	⑤
Q23	Determination of improvements in customer satisfaction	①	②	③	④	⑤
Q24	Have the customer service training budget	①	②	③	④	⑤
Q31	Use of quality techniques/tools to solve problems	①	②	③	④	⑤
Q32	Good communications between different department	①	②	③	④	⑤
Q33	Work standards are based on quality and quantity rather than quantity alone	①	②	③	④	⑤
Q34	effective tip-down and bottom-up communication	①	②	③	④	⑤
Q41	Implementation of strategies focused on quality	①	②	③	④	⑤
Q42	Degree of participation by major department heads in the quality improvement process	①	②	③	④	⑤
Q43	There are varies of quality activities	①	②	③	④	⑤
Q44	Self-inspection of work by workers	①	②	③	④	⑤
Q45	Good relation with suppliers	①	②	③	④	⑤
Q51	Reduce material handling	①	②	③	④	⑤
Q52	Design for manufacturability	①	②	③	④	⑤
Q53	Reduce cycle time	①	②	③	④	⑤
Q54	Reduce setup time	①	②	③	④	⑤
Q55	Reduce unit cost	①	②	③	④	⑤
P11	The plant is kept clean at all times, and easy to find tools	①	②	③	④	⑤
P12	Production employee dedicates a portion of every day solely to maintenance	①	②	③	④	⑤
P13	Many problems have been solved through small group sessions	①	②	③	④	⑤
P14	Employees are cross trained so that they can fill in for others if necessary	①	②	③	④	⑤
P21	Maintenance department focuses on assisting machine operators who perform their own preventive maintenance	①	②	③	④	⑤
P22	Information on productivity is readily available to employees	①	②	③	④	⑤
P23	Emphasize good maintenance as a strategy for achieving quality and schedule compliance	①	②	③	④	⑤
P24	To have a separate shift, or part of a shift, reserved each day for maintenance activities	①	②	③	④	⑤
P31	Maintenance department focuses on preventive maintenance	①	②	③	④	⑤
P32	Have the evaluation of equipment failure	①	②	③	④	⑤
P33	Classify the facility and evaluate the importance of equipment	①	②	③	④	⑤
P34	The equipment failure and MP information are in control	①	②	③	④	⑤
P41	To actively develop proprietary equipment	①	②	③	④	⑤
P42	Rely on vendors for most of our equipment	①	②	③	④	⑤
P43	Have equipment which is protected by the firm's patents	①	②	③	④	⑤
P44	Proprietary equipment helps us gain a competitive advantage	①	②	③	④	⑤

①Strongly disagree ②Disagree ③Average ④Agree ⑤Strongly agree

C11	Programs to develop team work between employees	①	②	③	④	⑤
C12	Quality-related training given to managers, supervisors and employees	①	②	③	④	⑤
C13	Have organization-wide training and development process for all employees	①	②	③	④	⑤
C14	Employees are trained in statistical improvement techniques	①	②	③	④	⑤
C15	Quality awareness building among employees is ongoing	①	②	③	④	⑤
C16	Management training in quality principles	①	②	③	④	⑤
C21	Top management assumes responsibilities for quality performance	①	②	③	④	⑤
C22	Top management supports long-term quality improvement process	①	②	③	④	⑤
C23	Commitment of the top management to employee training	①	②	③	④	⑤
C24	Degree to which the top management considers quality improvement as a way to increase profits	①	②	③	④	⑤
C25	Plant management is personally involved in quality improvement projects	①	②	③	④	⑤
C26	Plant management creates and communicates a vision focused on quality improvement	①	②	③	④	⑤
C31	Quality circle or employee involvement type programs are implemented	①	②	③	④	⑤
C32	Employees involve in design and planning	①	②	③	④	⑤
C33	Top management pushed decision making to the lowest practical level	①	②	③	④	⑤
C34	Employees are recognized for superior quality performance	①	②	③	④	⑤
M11	Quality cost decreased significantly.	①	②	③	④	⑤
M12	Customer complaints decreased significantly	①	②	③	④	⑤
M13	Conformance to specifications decreased significantly	①	②	③	④	⑤
M21	Manufacturing cost decreased significantly	①	②	③	④	⑤
M22	Inventory turnover cost decreased significantly	①	②	③	④	⑤
M31	On-time delivery increased significantly	①	②	③	④	⑤
M32	Fast delivery turnover decreased significantly	①	②	③	④	⑤
M41	Production efficiency increased significantly	①	②	③	④	⑤
M42	Inferior product volume decreased significantly	①	②	③	④	⑤
M43	Product changeover flexibility increased significantly	①	②	③	④	⑤
M44	Product mix flexibility increased significantly	①	②	③	④	⑤

1. Your major business in your company is:

☐ Food industry ☐ Paper industry ☐ Textile industry ☐ IT industry
☐ Iron & steel industry ☐ Plastic industry ☐ Automobile industry ☐ Electric machinery
☐ Shipping industry ☐ Glass industry ☐ Conveyance industry ☐ Others
☐ Cement industry ☐ Construction industry ☐ Rubber industry

2. Your company is:

☐ Foreign corporation ☐ Small & medium enterprise ☐ large enterprise

3. The capital of your company is:

☐ Less than 50 million ☐ 0.5-1 billion ☐ 10-50 billion
☐ 50-100 million ☐ 1-10 billion ☐ above 50 billion

4. How many employees are there in your company?

☐ Less than 50 ☐ 51-100 ☐ 101-200 ☐ 201-500 ☐ Above 500

5. What's your position

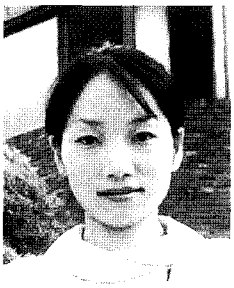
☐ President ☐ Plant manager ☐ Engineer
☐ Chief executive manager ☐ Manager ☐ Others

6. How long has your company come into existence?

☐ Less than 2 years ☐ 6-10 years ☐ above 21 years
☐ 2-5 years ☐ 11-20 years

저 자 소 개

최 연 홍



현 명지대학교 산업공학과 박사 과정

주소: 경기도 용인시 남동 산38-2 명지대학교 산업공학과 제1공학관 537호

김 창 은

TEXAS A&M 석, 박사학위 취득, 현재 명지대학교 산업공학과 교수로 재직 중

주소: 경기도 용인시 남동 산38-2 명지대학교 산업공학과 제1공학관 535호