The Study of TQM Implementation and Competitiveness for High Technology Industries

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Abstract

The competitiveness and the performance can be improved by implementing Total Quality Management (TQM). In this search, the relationship between TQM implementation and competitiveness improvement is studied for the practical cases at high technology industries in Taiwan. The industry type, company scale, and management attribute are moderate variables. The research results include (1) Eight perspectives of TQM critical factors, (2) Seven perspectives of competitiveness, (3) Better competitiveness with high TQM implementation at high technology industries, (4) The effect of industry type, company scale, and management attribute on the relationship between TQM and competitiveness, (5) The effect of industry type, company scale, and management attribute on TQM, and (6) The effect of industry type, company scale, and management attribute on the competitiveness. The practical study can be used to give the managers information for the competitiveness and performance improvement at high technology industries.

Key words: High technology, total quality management, and competitiveness

Introduction

The high-tech manufactures in Taiwan have gradually played an increasingly vital role in the global market for the past two to three decades, especially this phenomena has been a tragedy evidenced by the 921 earthquake hit in Taiwan back in 1999 (March, 2001, Business Week). The competitiveness is severe at high technology industries, and then affects the economy growth due to labor shortage, environment protection conception and industry change. Total Quality Management (TQM) has been carried out to improve the productivity, the competitiveness, market share, and the profit in many practical cases in Japan, Europe and USA, etc. (Wayhan & Balderson, 2007; Ugboro & Obeng, 2000; Parzinger et al., 1997; Reed et al., 2000; Parkin & Parkin, 1996; Saraph et al., 1989; Bou & Beltran, 2005; Hafeez et al., 2006).

The customer oriented principle is crucial in TQM to integrate the industries, solve the

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problems, improve the quality of service and products and obtain high market share. The employees can be also encouraged in the cooperative working environment to satisfy the internal and external customers. The management performance can be continuously improved by implementing TQM.

In the research, the conceptual research framework is obtained by means of literature review, case study, preliminary study, domain expert interview, and principal component analysis. The statistical analyses are then used to analyze the relationships between eight dimensions of TQM and seven perspectives of competitiveness at high technology industries selected from top 1000 companies in common wealth magazine. This paper presents the effect of industry type, company scale, and management attribute on the relationship between TQM and competitiveness. The effect of industry type, company scale, and management attribute on TQM and the competitiveness are also studied respectively. The empirical study can be used to give the managers information for the competitiveness and performance improvement resulted from TQM at high technology industries.

The high technology industries, TQM, competitiveness, and the effect of TQM on competitiveness are studied in Section 2. The conceptual research framework and the hypotheses are presented in Section 3. The data analyses and the relevant results are illustrated in Section 4, 5, and 6. Finally, the conclusion and the recommendation are presented.

Literature Review

TQM is a management system, a managerial principle, a fundamental implementation of continuous improvement, the use of human resource management and quantitative methods, and the quality improvement of service and all processes in the organization to satisfy the present and future requirements (Reed et al., 2000; Hartz & Kanji, 1998; Sorensen & Weber, 1994; Rao et al., 1997; Sureshchandar et al., 2002; Lai et al., 2002; Black & Porter, 1996; Quazi et al., 2002). The involvement of all employees, the satisfaction of employees and the customers, the continuous improvement, and the quality of the products/ service and the processes are also emphasized in TQM (Adamson, 2005; Idris & Zairi, 2006; Chen et al., 2005; Beheshti & Lollar, 2003; Scheuermann et al., 1997; Hafeez et al., 2006). The conception, the strategies, the tools, and the activities are included in TQM, which is a complex process with respect to all employees and the activities. Many academic and practical studies were presented about the critical dimensions of TQM implementation (Warwood & Roberts, 2004; Dooley & Flor, 1998; Black & Porter, 1996; Yeung & Armstrong, 2005; Bou & Beltran, 2005; Lin & Chang, 2006; Venkateswarlu & Nilakant, 2005; Fuentes et al., 2006; Yusuf et al., 2007; Oakland, 2005; Beheshti & Lollar, 2003).

The competitive priorities in the manufacturing project survey are identified, and include eight items such as consistency of quality, high functional product, reliable delivery, low price, speedy transportation, rapid design change, after-sale service, and quick quantity change (Ferdows et al., 1985). The priority after questionnaire analysis related to the competitiveness can be shown as the following sequence: (1) quality, reliability, and function, (2) product design and technology, (3) cost, (4) process capability, flexibility, response, and adaptability, (5) experience, and (6) service (Swamidass, 1986). The strategies and management to increase the competitiveness can be crucial for high technology companies (Fernandez & Nieto, 2006; Yang et al., 2005; Cooke, 2004; Wink, 2003; Lari, 2002; Boer & During, 2001; Arvanitis et al., 2006; Tien et al., 2007).

Performance evaluation is also crucial for the competitiveness. The performance can be categorized as financial performance, enterprise performance, and organization performance (Veakatraman and Ramanujam, 1986). The growth of return on asset, sales, and return on sales can be used to evaluate the financial benefit (Swamidass and Newwell, 1987). The short term performance, long term performance, productivity, financial benefit, competitiveness, sales growth, benefit growth, and market share can be the management measures (Madu et al., 1996). Balanced scorecard including four perspectives of finance, customer satisfaction, internal process, learning and growth can be used to evaluate the performance (Kaplan and Norton, 1996). In this research, the competitiveness can cover the scope of research and development, innovation, production, marketing, finance, and management performance.

Quality, productivity, and competitiveness can be improved through quality management (Deming, 1981; Warwood & Roberts, 2004; Quazi et al., 2002; Meegan & Taylor, 1997; Rao et al., 1997). Quality improvement can result in rework cost reduction, on time delivery, error reduction, incident delay prevention, lead time reduction, machine and material efficiency improvement, productivity improvement, the increase in market share with better quality and lower price, continuous management, more work opportunity and higher morality (Deming, 1982). Quality improvement can also be used to reduce the cost, and then enhance the reputation, the control over the price, the market share, and the financial benefit (Garvin, 1984). Quality is crucial to increase the reliability and productivity, enhance the competitiveness, reduce the rework and scrap costs, reduce the customer's complaint, reduce after-service and production costs, and increase the financial benefit (Ferdows et al., 1992).

In light of the above, a demand arises for studies aimed at clarifying how TQM relates to competiveness. By establishing the dimensions of TQM that relate to competitiveness dimensions and determining whether there are TQM configurations that favor the competitiveness elements.

Research Methodology

In this research, the critical dimensions of TQM are the independent variables and the dimensions of competitiveness are the dependent variables, and the relationship between TQM and the competitiveness is studied. The conceptual research framework is presented as Figure 1.

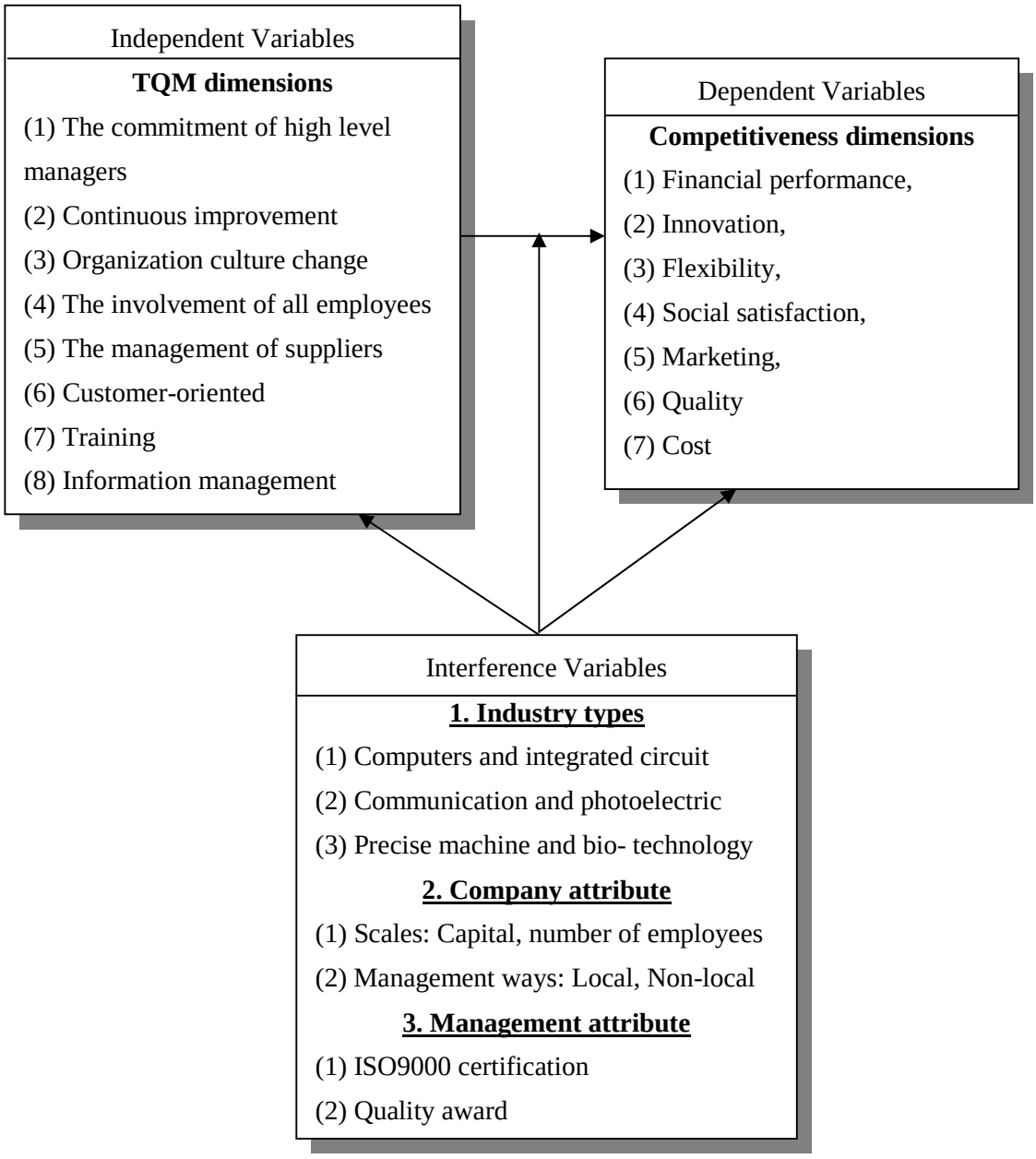

Figure 1. Conceptual Research Framework

TQM implementation can improve the competitiveness of production, marketing, and management performance (Yang et al., 2005; Cooke, 2004; Wink, 2003; Lari, 2002; Boer & During, 2001; Arvanitis et al., 2006). To verify the relationship between TQM implementation and the competitiveness, the following hypothesis can be posted:

Hypothesis 1: The effect of TQM implementation on the competitiveness is significant

for high technology industries.

The effect of TQM and the competitiveness of research and development, material sourcing, production, marketing, strategy planning for different high technology industries can be significantly different (Reed et al., 2000; Fernandez & Nieto, 2006; Tien et al., 2007). Thus, the following hypothesis arises:

Hypothesis 2: The effect of TQM and the competitiveness for different high technology industries can be significantly different.

The companies with large scale have systematical management, sufficient source of capital, human resource and material, and they are capable to implement TQM (Ahire and Golhar, 1996). Therefore, the hypothesis is shown as the following:

Hypothesis 3: The effect of TQM and the competitiveness for the companies with different management scale can be significantly different.

The source of capital can result in different management conception, and then affect TQM implementation (Swamidass and Newwell, 1987). Hence, the following hypothesis should be considered:

Hypothesis 4: The effect of TQM and the competitiveness for the companies with different management conception can be significantly different.

ISO9000 is the method for TQM since ISO9000 system can be the structure of quality management and TQM is the strategy (Corrigan, 2004; Samuel, 1994). Hence, ISO9000 certification may affect TQM implementation, which can lead us to the following hypothesis:

Hypothesis 5: The effect of ISO9000 certification on TQM and the competitiveness is significant.

The quality award is to set up a quality management model by following the audit standards in order to improve the competitiveness and obtain high quality products/service, and it can be related to TQM implementation (Corrigan, 2004; Samuel, 1994). Hence, the following hypothesis can be presented:

Hypothesis 6: The effect of quality award on TQM and the competitiveness is significant.

The statistical methods in this study include descriptive statistical analysis, principal component analysis, reliability analysis, validity analysis, correlation analysis, multi-regression analysis, Schefee multiple tests and t-hypothesis test. Each will be elaborated in the relevant sections.

The Effect of Interference Variables on TQM and Competitiveness

The relationship between TQM and the competitiveness is studied by using correlation analysis. Seven dimensions of the competitiveness and eight dimensions of TQM are positively correlated. The regression model of TQM on the competitiveness is then used, and the proportion of the variance illustrated by the regression model is R^2=0.7555, which is shown in Table 1. The competitiveness is significantly affected by the dimensions of TQM including the commitment of high level managers, continuous improvement, organization culture change, the involvement of all employees, customer-oriented, and training.

Table 1. Regression analysis of TQM on the competitiveness

Competitiveness dimensions	Competi-tion (Y)	Financial perfor-mance (Y1)	Innova-tion (Y2)	Flexibility (Y3)	Social satisfac-tion (Y4)	Marketing (Y5)	Quality (Y6)	Cost (Y7)
TQM dimensions	Estimated value	Estimated value	Estimated value	Estimated value	Estimated value	Estimated value	Estimated value	Estimated value
Intercept	29.6145***	8.6681***	3.7099***	3.8982***	3.4360***	1.0325***	3.2090***	2.5397***
Commitment of senior managers (X1)	0.1302***	0.1400**	0.0280	0.0169	0.0506**	0.0207**	0.0155	0.0513***
Continuous improvement(X2)	0.6989***	0.2559***	0.1009***	0.0391	0.1154***	0.0187*	0.0875***	0.0297*
Organization culture change (X3)	0.8817***	0.3343***	0.0428*	0.1568***	0.0378	0.0229**	0.1149***	0.0296*
Involvement of all employees (X4)	0.6918***	0.0001	0.0030	0.1320***	0.0108	0.0059	0.0076	0.0014
Supplier management(X5)	0.1599	0.0143	0.0345	0.0108	0.0292	0.18131***	0.0816***	0.0248
Customer oriented (X6)	0.8692**	0.3189**	0.2481***	0.2823***	0.2975***	0.0440**	0.2303***	0.0701
Training(X7)	1.0328***	0.2257**	0.1552***	0.0136	0.0115	0.0963***	0.0083	0.1967**
Information technology (X8)	0.1226	0.0897	0.0236	0.0034	0.0256	0.2877***	0.0181	0.016***
Adj R-Square	0.7555	0.7873	0.7036	0.6991	0.7275	0.9167	0.7502	0.7446
p -value	0.0001***	0.0001***	0.0001***	0.0001***	0.0001***	0.0001***	0.0001***	0.0001***
***:p-value<0.01, **:p-value<0.05, *:p-value<0.1								

In this research, the competitiveness of high technology companies can be categorized as the groups of high, medium and low competitiveness. The discriminated analysis is then used to verify the stability of grouping, and the confusion matrix is obtained and the rate of grouping correction is 96.34%.

The result of MANOVA analysis shows that eight critical dimensions of TQM at the groups of high, medium and low competitiveness are significant. The Scheffe's multiple test is further analyzed, and all the mean of eight critical dimensions of TQM for high competitive group can be greater than the mean for medium and low competitive groups.

The mean of eight critical dimensions of TQM for medium competitive group is greater than the mean for low competitive groups. Hence, the TQM implementation for high technology industries significantly affects the competitiveness, and Hypothesis 1 is then verified.

The Effect of Interference Variables on TQM

The effect of different kinds of industries on TQM

The high technology companies in Taiwan with respect to (1) computers and integrated circuit, (2) communication and photoelectric and (3) precise machine and bio-technology are analyzed. MANOVA analysis is used to study the effect of different kinds of industries on TQM. The results show that the effect of information technology of TQM is significantly different for different kinds of industries. The information technology in the industries of computers and integrated circuit is much more applicable than the industries of communication and photoelectric and precise machine and bio-technology by further using Scheffe's multiple tests.

The effect of different number of employees on TQM

Commitment of senior managers and supplier management of TQM are significant for different number of employees. The commitment of senior managers of TQM is significant for high technology industries with more than 501 employees. The supplier management of TQM is significant for high technology industries with 201-500 or less than 200 employees.

The effect of different management ways on TQM

Organization culture change of TQM is significantly different for different management ways with local or non-local capital source. The implementation of organization culture change for non-local high technology industries is better than local high technology industries.

The effect of ISO9000 certification on TQM

Commitment of senior managers and organization culture change of TQM are significantly different for the industries with or without ISO9000 certification. The TQM implementation for high technology industries with ISO9000 certification is better than the industries without ISO9000 certification.

The effect of quality awards on TQM

Commitment of senior managers, organization culture change, the involvement of all employees and information technology of TQM are significantly different for the industries with or without quality award. The TQM implementation for high technology industries with quality award is better than the industries without quality award.

The Effect of Interference Variables on Competitiveness

The effect of different kinds of industries on competitiveness

The effect of different kinds of industries on the competitiveness is studied by using MANOVA analysis and Scheffe's multiple tests with respect to the high technology companies in Taiwan such as (1) computers and integrated circuit, (2) communication and photoelectric and (3) precise machine and bio-technology. The results show that the innovation and the marketing of competitiveness are significantly different for different kinds of industries. The innovation in the industries of computers and integrated circuit is much better than the industries of communication and photoelectric and precise machine and bio-technology. The marketing in the industries of communication and photoelectric is better than the others.

The effect of different management scales on competitiveness

The flexibility and the cost of competitiveness are significantly different for different number of employees. The flexibility in the industries with many employees is much better than the industries without many people. The cost in the industries without many employees is lower than the other.

The effect of different management ways on competitiveness

The dimensions of the innovation, the cost and the flexibility of the competitiveness are significantly different for local and non-local industries. The innovation and the cost in the local industries are better than the non-local industries. The flexibility in the local industries is better than non-local industries.

The effect of ISO9000 certification on competitiveness

The marketing and the quality of the competitiveness are significantly different for the industries with or without ISO9000 certification. The marketing and the quality in the high technology industries with ISO9000 certification is better than the industries without ISO9000 certification.

The effect of quality awards on competitiveness

The dimensions of financial performance, social satisfaction, the quality of the competitiveness are significantly different for the industries with or without quality award. The financial performance, social satisfaction, and the quality for the high technology industries with quality award are better than the industries without quality award.

Conclusion

In this research, eight perspectives of TQM and seven perspectives of the competitiveness are analyzed by using factor analysis and relevant statistical analysis. One one hand, eight critical dimensions of TQM are obtained, namely, (1) the commitment of high level managers, (2) continuous improvement, (3) organization culture change, (4) the

involvement of all employees, (5) the management of suppliers, (6) customer-oriented, (7) training, and (8) information management. On the other hand, seven critical perspectives for the competitiveness are obtained in terms of (1) financial performance, (2) innovation, (3) flexibility, (4) social satisfaction, (5) marketing, (6) quality, and (7) cost. The following conclusion can be obtained:

1. The effect of the critical dimensions of TQM including the commitment of senior managers, continuous improvement, organization culture change, the involvement of all employees, customer-oriented, and the training on the competitiveness is significantly different. Hence, the performance of TQM implementation has significant influence on the competitiveness due to the conception of high quality and customer-oriented.
2. The effect of the critical dimensions of TQM including the commitment of senior managers, continuous improvement, organization culture change, the involvement of all employees, customer-oriented, and the training on the financial performance of competitiveness is significantly different.
3. The effect of the critical dimensions of TQM including continuous improvement, organization culture change, customer-oriented, and the training on the innovation of competitiveness is significantly different.
4. The effect of the critical dimensions of TQM including organization culture change, the involvement of all employees, and customer-oriented on the flexibility of competitiveness is significantly different.
5. The effect of the critical dimensions of TQM including the commitment of senior managers, continuous improvement, and customer-oriented on the social satisfaction of competitiveness is significantly different.
6. The effect of the critical dimensions of TQM including the commitment of senior managers, continuous improvement, organization culture change, the management of suppliers, the involvement of all employees, customer-oriented, the training, and information management on the marketing of competitiveness is significantly different.
7. The effect of the critical dimensions of TQM including continuous improvement, organization culture change, the management of suppliers, and customer-oriented on the quality of competitiveness is significantly different.
8. The effect of the critical dimensions of TQM including the commitment of senior managers, continuous improvement, organization culture change, the training, and information management on the cost of competitiveness is significantly different.

The high technology companies in Taiwan with respect to (1) computers and integrated circuit, (2) communication and photoelectric and (3) precise machine and

bio-technology are analyzed. Some interference variables such as industry types, management scales, management ways, ISO9000 certification, quality award are also shown to be crucial to improve the competitiveness and TQM implementation. The financial performance, the flexibility, and social satisfaction of the competitiveness are the critical dimensions for the high technology industries with large management scales. The commitment of senior managers and the training are crucial for the high technology industries with small management scales.

The following conclusion can be obtained:

1. For computers and integrated circuit industries, the effect of organization culture change, the involvement of all employees and training of TQM on competitiveness is significant.
2. For communication and photoelectric industries, the effect of the commitment of high level managers, continuous improvement, organization culture change and the involvement of all employees of TQM on competitiveness is significant.
3. For precise machine and bio-technology industries, the effect of continuous improvement, the involvement of all employees, training and information management of TQM on competitiveness is significant.
4. The effect of critical dimensions of TQM except organization culture change on the competitiveness is significantly different for different number of employees.
5. The effect of critical dimensions of TQM except continuous improvement, organization culture change and the involvement of all employees on the competitiveness is significantly different for different asset.
6. The effect of critical dimensions of TQM except organization culture change and the involvement of all employees on the competitiveness is significantly different for different management ways with local or non-local capital source.
7. The effect of critical dimensions of TQM except the training and the involvement of all employees on the competitiveness is significantly different for the industries with or without ISO9000 certification.
8. The effect of critical dimensions of TQM except the training on the competitiveness is significantly different for the industries with or without quality award.

References

Adamson, I., 2005. Knowledge management–the next generation of TQM? *Total Quality Management & Business Excellence*, 16(8): 987-1000.

Ahire, S. and D. Golhar, 1996. Quality Management in Large vs Small Firms. *Journal of Small Business Management*, 34(2).

Beheshti, H. and J. Lollar, 2003. An empirical study of US SMEs using TQM. *Total*

Quality Management & Business Excellence, 14(8): 839-847.

Boer, H. and W. During, 2001. Innovation, what innovation? A comparison between product, process and organisational innovation. *International Journal of Technology Management*, 22(1): 83-107.

Bou, J. and I. Beltrán, 2005. Total quality management, high-commitment human resource strategy and firm performance: an empirical study. *Total Quality Management & Business Excellence*, 16(1): 71-86.

Chen, S., H. Chen, et al., 2005. An empirical study of software process maturity, TQM practices and organizational characteristics in Taiwanese companies. *Total Quality Management & Business Excellence*, 16(10): 1091-1102.

Cooke, P., 2004. The role of research in regional innovation systems: new models meeting knowledge economy demands. *International Journal of Technology Management*, 28(3): 507-533.

Corrigan, J., 1994. Is ISO 9000 the path to TQM? *Quality Progress*, 27(5): 33-38.

Dooley, K. and R. Flor, 1998. Perceptions of success and failure in TQM initiatives. *Journal of Quality Management*, 3(2): 157-174.

Fernandez, Z. and M. Nieto, 2006. The Internet: Competitive strategy and boundaries of the firm. *International Journal of Technology Management*, 35(1): 182-195.

Fuentes, M., F. Montes, et al., 2006. Total quality management, strategic orientation and organizational performance: the case of Spanish companies. *Total Quality Management & Business Excellence*, 17(3): 303-323.

Hafeez, K., N. Malak, et al., 2006. A framework for TQM to achieve business excellence. *Total Quality Management & Business Excellence*, 17(9): 1213-1229.

Hartz, O., 1998. Development of strategies for total quality management in large industrial companies and small and medium-sized enterprises. *Total Quality Management & Business Excellence*, 9(4): 112-115.

Idris, M. and M. Zairi, 2006. Sustaining TQM: a synthesis of literature and proposed research framework. *Total Quality Management & Business Excellence*, 17(9): 1245-1260.

Lai, K., T. Weerakoon, et al., 2002. The state of quality management implementation: A cross-sectional study of quality-oriented companies in Hong Kong. *Total Quality Management & Business Excellence*, 13(1): 29-38.

Lin, C. and S. Chang, 2006. Exploring TQM's impact on the causal linkage between manufacturing objective and organizational performance. *Total Quality Management & Business Excellence*, 17(4): 465-484.

Meegan, S. and W. Taylor, 1997. Factors influencing a successful transition from ISO 9000 to TQM. *International Journal of Quality & Reliability Management*, 14(2): 100-17.

Oakland, J., 2005. From quality to excellence in the 21st century. *Total Quality Management & Business Excellence*, 16(8): 1053-1060.

Parkin, M. and R. Parkin, 1996. The impact of TQM in UK SMEs. *Industrial Management and Data Systems*, 96(4): 6-10.

Parzinger, M., N. Ramarapu, et al., 1997. A stage-wise application of total quality management through the product life cycle. *Industrial Management and Data Systems*: 125-130.

Quazi, H., C. Hong, et al., 2002. Impact of ISO 9000 certification on quality management practices: A comparative study. *Total Quality Management & Business Excellence*, 13(1): 53-67.

Rao, S., T. Luis, et al., 1997. Does ISO 9000 have an effect on quality management practices? An international empirical study. *Total Quality Management & Business Excellence*, 8(6): 335-346.

Reed, R., D. Lemak, et al., 2000. Total quality management and sustainable competitive advantage. *Journal of Quality Management*, 5(1): 5-26.

Scheuermann, L., Z. Zhu, et al., 1997. TQM success efforts: use more quantitative or qualitative tools? *Industrial Management & Data Systems*, 92: 264-270.

Sureshchandar, G., C. Rajendran, et al., 2001. A conceptual model for total quality management in service organizations. *Total Quality Management & Business Excellence*, 12(3): 343-363.

Tien, S., C. Chiu, et al., 2007. The impact of innovation management implementation on enterprise competitiveness among Taiwan's high-tech manufacturers. *International Journal of Technology Management*, 40(1): 7-44.

Ugboro, I. and K. Obeng, 2000. Top management leadership, employee empowerment, job satisfaction, and customer satisfaction in TQM organizations: an empirical study. *Journal of Quality Management*, 5(2): 247-272.

Venkateswarlu, P. and V. Nilakant, 2005. Adoption and persistence of TQM programmes–case studies of five New Zealand organizations. *Total Quality Management & Business Excellence*, 16(7): 807-825.

Wink, R., 2003. Transregional effects of knowledge management: Implications for policy and evaluation design. *International Journal of Technology Management*, 26(2): 421-438.

Yang, D., P. Ghauri, et al., 2005. Competitive analysis of the software industry in China. *International Journal of Technology Management*, 29(1): 64-91.

Yeung, V. and R. Armstrong, 2005. The management pattern of adopting TQM in Hong Kong companies. *Total Quality Management & Business Excellence*, 16(2): 171-183.