Development of A Total Management System Model with Empirical Evidences

Y K Chan, Phil Gaffney, L C Koo and K C Tao

Abstract

To meet the organizational development needs of the MTR Corporation Ltd (MTR), a metro railway in Hong Kong, a new Total Management System (TMS) model has been formulated. The new model embedded with TQM philosophy integrates all management systems that can manage the total business of the railway operations. The TMS has hypothesised with seven constructs based on the common factors of four National Quality Award criteria and critical factors of seven empirical studies. Holistic implementation initiatives were formulated after extensive self-assessment and the TQM implementation instruments of three research studies. The model was successfully implemented in the OED as a pilot and then the whole operations railway subsequently. A TMS implementation instrument comprising 49 initiatives was then developed, which became the contents of the questionnaire. A questionnaire survey based on a sample of 279 staff was conducted to measure the performance in the seven constructs of the TMS model. Structural Equation Modeling (SEM) method was used for model testing. Results of the test indicated that the data generally fitted the model.

Key Words: TQM, IMS, SEM

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Chan, Y. K., Gaffney, P., Koo, L. C. and Tao, K. C. (2003) "Development of A Total management System Model with Empirical Evidences" Asia International Open University (Macau) Journal, pp. 1-11

摘 要

自1998年以來，香港地下鐵路有限公司開發並實施一套新的管理系統模式——「全面管理系統模式（TQM）」。該模式涵括全面品質管理（TQM）之理念，並整合了現有的管理系統令其可以全面地管理鐵路營運業務。TMS模式之假設由國家品質獎之七個標準要求以及參考七種實驗研究之要素所構成，全部構成之實施倡議經過該公司之自我檢測而制定。新模式已在操作工程部試行成功，並再推廣至整個車務部。為量度該模式及其構成之成功，一個包括279個員工樣本之問卷調查經已完成，其結果由結構方程式模式測驗法測試所得，得到之數據顯示合乎該模式的制定。

關鍵詞：全面質量管理、全面管理系統、結構性模式

1. The Total Management Model

While there are many successful cases where application of the TQM model has reaped substantial benefits (Corcoran, 1996; Hayday, 1996 and Massey, 1996), there is little attempt to further develop the TQM model to meet organisations' development needs (Zain, et al., 2001). The purpose of this paper is introduced the process of development of a fit-for-purpose management system model to meet the development needs of the MTR. The new management system model is formulated based on the previous research results on TQM, the common factors of four National Quality Awards (Japan, USA, Europe and Australia) and the critical factors developed by seven studies. These studies include those of Saraph et al. (1989), Flynn et al. (1994), Anderson et al. (1995), Powell (1995), Handfield and Ghosh (1995), Black and Porter (1996), and Ahire et al. (1996).

The TMS is defined as a management system model, which focuses on core business processes, integrates various management standards, embraces the business excellence model criteria, and is able to manage the total railway operations with a view to improving overall organisational performance. To this end, the following considerations have been incorporated:

1. The system should be based on ISO 9000 management framework (i.e. a systematic documentation structure with system assurance features – management review and audit);
2. It should be able to integrate all necessary management standards (e.g. ISO

9000, ISO 14000, OSHS18000, etc.) into a single management framework which focuses on core business processes; and

3. Incorporation of the TQM philosophy (such as the seven categories of the Malcolm Baldrige National Quality Award judging criteria).

With an aim to formulate equivalent attributes to be used by the TMS model, seven critical factors were identified as a result of the benchmarking with NQA criteria, other TQM research results and discussions in the focus group consisting of senior management team of the Operations Division of the Company. These critical factors have addressed the development needs of the MTR. The dynamic relationship of the TMS seven critical factors forms the proposed initial TMS model as shown in Figure 1 below:

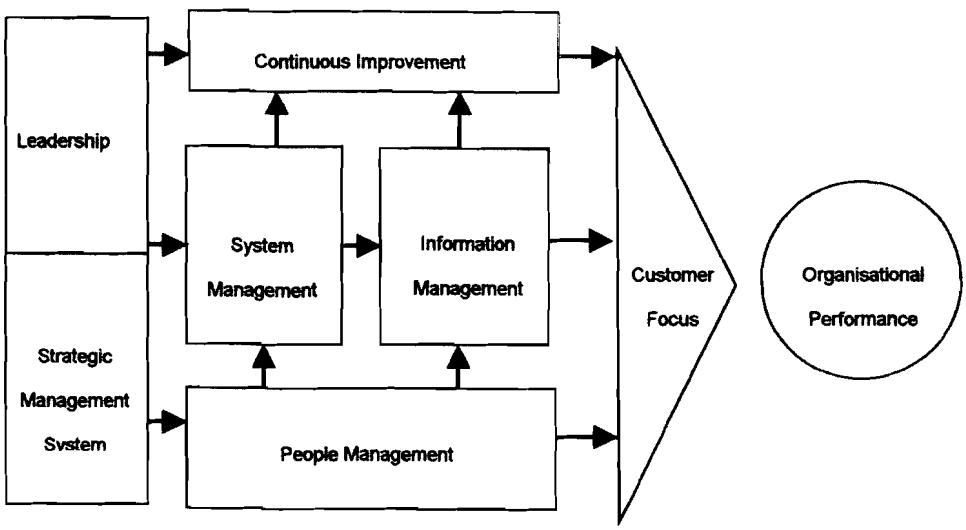


Figure 1 Initial Model of the TMS

Among the seven critical factors of the TMS model, the factors of *"leadership and strategic management"* are manifestations of the importance of senior management's role in the implementation of TQM. The *"process management and information management"* highlight the importance of streamlining the overall processes of the organisation. The *"people management"* addresses the importance of aligning teamwork towards the corporate goals. The *"continuous improvement"* is an important element to ensure the sustainability of the whole system and drive for continuous improvement. The *"customer focus and organisational performance"* are the means to ensure business results are achieved.

2. TMS Implementation Instrument

A comprehensive implementation instrument has then been formulated by establishing a customised self-assessment questionnaire. The questionnaire has subsequently formed an important part of the annual management review process with the aim to assess the extent of the TMS implementation and its effect on organisational performance.

A comparison between this instrument and other instruments has been conducted in order to identify the characteristics of this instrument. In this study, only three instruments are selected for this comparison. They were developed by Saraph et al. (1989), Flynn et al. (1994), and Ahire et al. (1996). The three instruments developed by the aforementioned researchers differ in terms of constructs and measuring items, and each instrument has its own strengths and weakness (their differences were addressed by Ahire et al. (1996). However, elements of these three instruments could not be totally adopted by this study since certain elements of these instruments are addressing the manufacturing environment. For example, elements such as "*SPC (statistical process control) is used in our plant*", "*we use Taguchi methods extensively*" and "*scrap rates of our primary product are readily available*" etc. are not applicable in the MTR.

The existing instruments developed by these researchers did, however, give some insights into developing the 49 TMS implementation initiatives that support the TMS implementation and the special characteristics of railway operations. They have been developed for measuring the six constructs of the TMS model and five items have been developed to measure the overall organisational performance (Figure 2). They have been used in the design of the questionnaire.

Since the aim of this study is to develop a fit-for-purpose system with a view to improving the organisational performance of the railway operations, the instrument has to be specially designed to address the burning issues of the MTR. Specific characteristics of the railway operations have to be taken account in its development. For example, issues such as safety, system integration and use of the cyber technology have been included.

3. Data Validation

The survey was based on a stratified random sample of 279 among 1116 staff covering all staff at every level across the Operation Division. A total of 261 survey questionnaires in anonymity were returned and the response rate came out to be 94%. The internal consistency test (Nunnally,

1967) indicated that the Cronbach's alpha ratios for all the components of the questionnaire are greater then 0.8, thus the responses within each main component are regarded to be reliable. The item analysis as suggested by Nunnally (1967) concluded that all items in the questionnaire had been appropriately assigned to scales. The confirmatory Factor Analysis with a cutoff loading of 0.55 has reduced the variables from 49 to 31. The reliability and validity analyses concluded that the data obtained through this instrument could be used in subsequent data analysis.

4. Development of the TMS Theoretical Model

Over the last 25 years, Structural Equation Modeling (SE) has become one of the most important data analysis techniques in social science (Kaplan, 1995). SEM has become a language to formulate social science theories, and a language to talk about the relationship between variables (Kaplan, 1995). SEM is used to study complex relationships among a series of variables, some of which can be directly measured and some of which cannot be measured. Hence, SEM is well suited for this study. It provides a straightforward method of dealing with multiple relationships simultaneously while providing statistical efficiency. The structural equation modeling software, AMOS version 3.6 (Arbuckle, 1997) has been employed in testing the theoretical models hypothesised in this research.

In order to empirically test the theoretical models hypothesised in this study, it is first necessary to formulate these theoretical constructs so that empirical investigation is possible. Therefore, a set of items to measure the constructs of the TMS model (consisting of leadership, people management, process management, information management, and continuous improvement, and customer focus) and constructs of organisational performance (including process performance, staff efficiency, safety performance, customer satisfaction and financial performance) has to be carefully developed. Items have been developed to tap as comprehensively as possible the conceptual domain of the theoretical constructs. The following diagram (Figure 2), which is translated from the proposed initial TMS model (Figure 1), demonstrates the hypotheses made for these constructs:

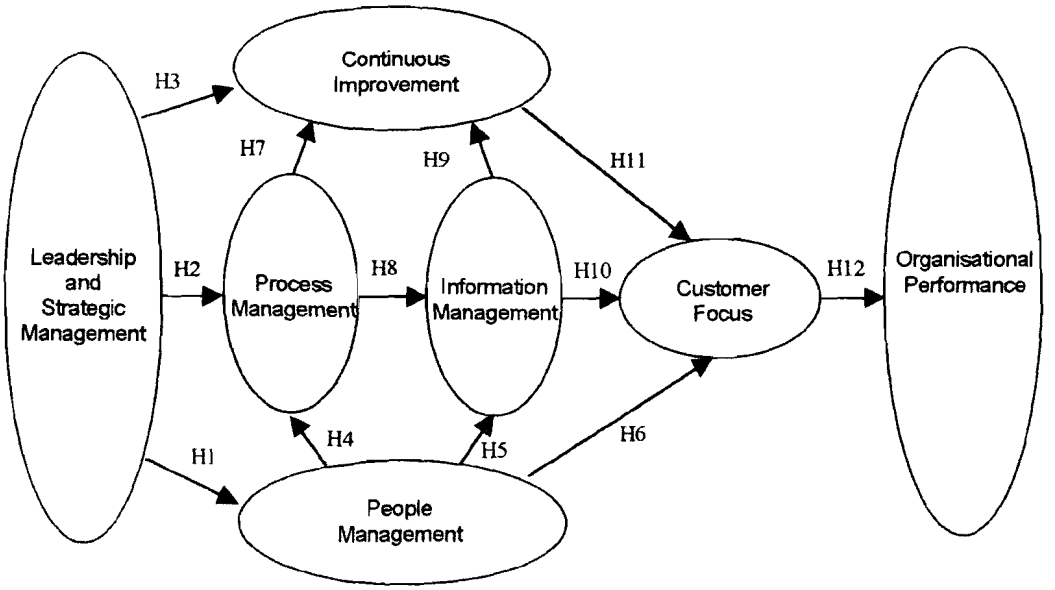


Figure 2 The Initial Theoretical Model of the TMS

This study investigates 12 hypotheses concerning the relationships among Leadership and Strategic Management, People Management, Process Management, Information Management, Continuous Improvement, Customer Focus and Organisational Performance. The 12 hypotheses to be tested are as follows:

Hypothesis H1: Leadership has a positive effect on people management
Hypothesis H2: Leadership has a positive effect on process management
Hypothesis H3: Leadership has a positive effect on continuous improvement
Hypothesis H4: People management has a positive effect on process management
Hypothesis H5: People management has a positive effect on information management
Hypothesis H6: *People management has a positive effect on customer focus*
Hypothesis H7: Process management has a positive effect on continuous improvement
Hypothesis H8: Process management has a positive effect on information management
Hypothesis H9: Information management has a positive effect on continuous improvement
Hypothesis H10: Information management has a positive effect on customer focus
Hypothesis H11: Continuous improvement has a positive effect on customer focus
Hypothesis H12: Customer focus has a positive effect on overall organisational performance

In these 12 hypotheses, organisational performance is a dependent variable, and the other six are independent variables.

5. Model Estimation

AMOS provides the following methods for estimating structural equation models: Maximum likelihood (ML), unweighted least squares (ULS), generalised least squares (GLS), Browne's asymptotically distribution-free criterion (BADFC), and scale-free least-squares (SFLS). According to De Jong (1999), ML estimates are consistent and efficient (they produce the most reliable estimates). Kemp (1999) and De Jong (1999) adopted the ML estimation for testing their theoretical models, which produced reliable results. Therefore, it is decided that the ML estimation method would be used for testing the theoretical model.

AMOS provides the Critical Ratio (CR) to identify whether the estimated path coefficients are significant or not, and have the hypothesised sign. In fact, the CRs are the t-values, which are the ratio of parameters estimated to the respective standard errors. For one-tail tests, a CR larger than 1.282 corresponding to p value<0.10 (weakly significant), a CR larger than 1.645 corresponds to p-value<0.05 (Moderately significant), and a CR larger than 2.326 corresponds to p-value<0.01 (Strongly significant) (Haenett and Murphy, 1985). It is noted that p-value (p) represents 1-p confidence that the relationship in the path are confirmed. The estimate (path coefficient) is the dependent or mediating variable for each unit change in the variable predicting it.

The estimates of the proposed model are listed in the second column and their CRs, which demonstrate whether these estimates are statistically significant or not, are shown in the third column of Table 1. These results indicate that among the 12 estimates, three are statistically insignificant. Deleting the insignificant paths one by one until all paths are significant, the results as illustrated in columns four and five are obtained, which demonstrate the other paths are significant at 0.01 levels. The CRs in the same table (Table 1) demonstrate all of the paths are significantly positive at 0.01 level (CR > 2.326). The resulting model is shown in Figure 3.

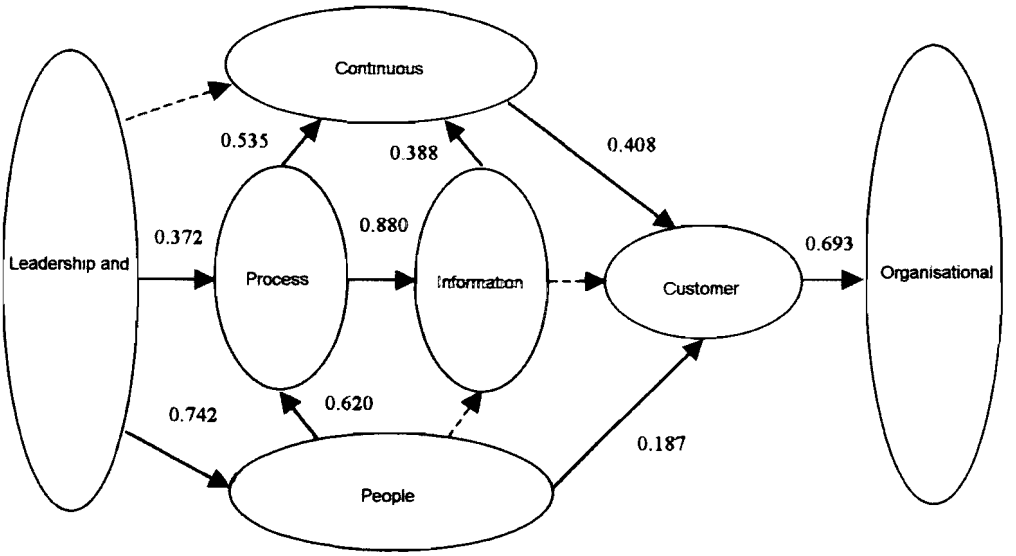
Path			Proposed Model		Revised Model	
			Estimate		Estimate	CR
			1	2	3	4
People Management	←	Leadership	0.739	10.645	0.741	10.663
Process Management	←	People Management	0.682	4.826	0.684	4.853
Process Management	←	Leadership	0.314	2.795	0.310	2.770
Information Management	←	Process Management	0.939	5.316	0.891	10.759
Information Management	←	People Management	-0.057	-0.310	Deleted	-
Continuous Improvement	←	Information Management	0.283	3.339	0.291	3.680
Continuous Improvement	←	Process Management	0.623	4.361	0.621	6.667
Continuous Improvement	←	Leadership	0.006	0.065	Deleted	-
Customer Focus	←	People Management	0.703	6.349	0.727	6.560
Customer Focus	←	Continuous Improvement	0.282	6.349	0.368	4.248
Customer Focus	←	Information Management	0.109	1.098	Deleted	-
Organisational Performance	←	Customer Focus	0.693	8.202	0.692	8.196

Table 1 Estimates and CRs of the Proposed and Revised Models

6. Overall Model Fit

In theoretical model testing, a major issue is whether the theoretical model is in conflict with reality as observed in the sample; namely, how well the theoretical model fits the data (De Jong, 1999). In AMOS, relative chi-square, also called normal chi-square, is adopted to evaluate the global fit, which are the only statistical based measures of goodness-of-fit available in a structural equation model (Byrne, 1998). Relative chi-square is the chi-square fit index divided by degree of freedom, in an attempt to make it less dependent on sample size. Carmines and Mclver (1981) state that relative chi-square should be in the range of 2 to 3 for an acceptable model. Kline (1998) says 3 or less is acceptable. Some researchers allow as high as 5 to consider a model

adequate fit, while others insist relative chi-square be two or less. AMOS lists relative chi-square as CMIN / DF (minimum sample discrepancy/degree of freedom). In this study, it is 2.09 (CMIN = 1374.53, DF = 656, CMIN / DF = 2.09), which is in the range of 2 to 3 used by convention, the null hypothesis that the model fits the data is accepted. The theoretical model of TMS is illustrated in Figure 3 below:



Note:

1. Upper figures estimate of path coefficients
2. The figures in the brackets are CRs.

Figure 3 The Final Theoretical Model of the TMS

The final TMS model is in fact a reflection of various implementation initiatives launched to facilitate the implementation of the TMS in both the OED and OD. The response of the questionnaire has outlined the perception of the staff on TMS implementation in both the OED and OD during the past few years. Though this empirical study verifies the cause and effect relationship of the seven constructs of the TMS model, it has been customised for application in the MTR. Hence the model is not the generic model that can be applied in other railways or other industries without further study.

7. Conclusion

The results of the SEM test indicate that, in contrary to what have been hypothesised in the initial

model, three hypotheses are not confirmed by data (leadership and strategic management has a positive effect on continuous improvement, people management has a positive effect on information management and information management has a positive effect on customer focus). These findings are in line with the current practice upon TMS implementation in the Operations Division as leadership and strategic management does not directly affect continuous improvement but rather through people within the organisation. On the other hand, in staff's perception, staffs are not directly managing information, the information system is designed and managed by functional departments, and information management does not provide customer information accessible by general staff. Several conclusions obtained from testing the hypothesised model are:

1. Leadership and strategic management has positive effects on people management and process management;
2. Leadership and strategic management does not have positive effects on continuous management;
3. People management has positive effects on information management and customer focus;
4. People management does not have positive effects on information management;
5. Process management has positive effects on information management and continuous management;
6. Information management has positive effects on continuous improvement but does not have a positive effect on customer focus;
7. Continuous improvement has positive effects on customer focus; and
8. Customer focus has positive effects on organisational performance.

Though the data fit the model quite well, it is important to view this study in the context of its limitation. First, data used to test the model came from 261 supervisory and managerial staff of the Operations Division, MTR. Strictly speaking, the generalisation is limited. Secondly, organisational performance data were obtained from the same group of staff, so the data and hence the research results might have been biased to the management side. The research findings have some practical implications. In this study, some hypotheses were not confirmed by the survey data. This disconfirmation does not imply these constructs are unimportant, and further investigation is being conducted to identify the problem areas of these constructs and implement them more effectively. For example, the top 10 strategic issues are published by management and staff members are encouraged to form work improvement teams to achieve them. Another example is the introduction of hand-held computers to station staff to help provide customers with the required information more promptly. Hence, information management is in their hands.

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