Identifying and Prioritization Effective Factors in TQM implementation Using AHP and DEMATEL Methods

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Abstract: The purpose of this paper is Identifying and Prioritization Effective Factors in TQM implementation Using AHP and DEMATEL Methods. TQM is universally accepted as one of the most understood change management programmes and is one of the strategies for confronting the global competitive challenge facing both manufacturing and service industries. The study involved a comprehensive literature survey as well as information and data collected in the Golrang Company in Iran. In this study were used two types of questionnaires, AHP questionnaire and DEMATEL questionnaire. After identified the hierarchical decision tree, In order to gather these data, AHP questionnaire is designed and distributed among 15 experts in Golrang Company. The study result shows that the main factors in TQM implementation are Management factors and quality factors (by AHP approach) and effective factors are Top management support and Quality management process (by DEMATEL approach).
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1. Introduction

Total quality management (TQM) is a holistic approach that seeks to integrate all organizational functions to focus on meeting customer needs and organizational objectives through the improvement of quality, productivity and competitiveness (Pfau, 1989). TQM philosophy emphasizes the role of internal and external customers and suppliers, and the involvement of employees in pursuit of continuous improvement (Oakland et al., 2002; Chang, 2006). Despite some criticism, TQM has gained widespread acceptance in both the academic and business communities (Claver et al., 2003; Chang, 2006). Extensive research focuses especially on the role of performance measurement in the context of TQM. Organizations wishing to implement TQM face therefore a necessity of profound changes in performance measurement (Sinclair and Zairi, 1995) and are in need of guidance and better understanding of the role of different performance measurement methods and systems. The objective of this paper is to provide guidance for future TQM adopters through investigation of existing practices implemented by a group of finalists in the total quality category of Canada Awards for Business Excellence. However, very often TQM has gone from buzzword to fad in many people's opinion (Bergquist et al., 2005). It is widely accepted that TQM emphasizes self-control, autonomy, and creativity among employees and requires active co-operation rather than mere compliance. In addition, TQM theory supports that internal and external information should be equally shared among all employees in order to encourage them to become responsible for quality improvement. However, although many articles have been written about the "basic principles and tools" of TQM and the various approaches taken to assure a successful implementation of TQM according to Dayton (2003) continue to remain complex and somewhat clouded.

TQM is still in the early stages of theory development. Furthermore, the future theoretical development incorporating "appropriate management theories" is still to come until TQM can reach a "refined" stage of development. TQM aims to provide organizations with a template for success through customer satisfaction. TQM initiatives must include an in-built culture of continuous improvement, which can help an organization satisfy the needs of its customers on an ongoing basis (Walsh et al., 2002). The concept of TQM provides the approach to realize the manufacturing strategy leading to fulfilment of corporate strategy. The principles and contents of TQM philosophy would increase a firm's commitment to quality and if they are applied correctly enhances the firm's competitive position. This is because the TQM principles support the business practices of cost

reduction, enhanced productivity, and improved quality of the products/outputs – i.e., it helps to support and fulfil the concept of excellence in manufacturing. Literature on TQM advocates the influence of human factors more as compared to other factors on implementation of TQM and business performance. Saad and Siha (2000) feel the visible (or tangible) variables such as technology, structure and strategy have a relatively small impact on TQM effectiveness compared with largely hidden and intangible variables such as values, attitudes and perception. These factors have also been classified as hard and soft elements or hardware and software determinants. Improvement in the soft elements is important since there is adequate research proving that business performance is more heavily influenced by these elements of TQM (Gotzamani and Tsiotras, 2001). The TQM concept is used by an increasing number of organizations to this end. The available empirical evidence also supports the assertion that implementation of TQM improves the profitability and competitive position of the organization.

2. Literature review

2.1. TQM literature

Total quality management (TQM) is considered by many to be the management paradigm capable of facilitating the attainment of continuous improvement and external focus. This accounts for the attention paid to TQM by all sides of commerce and industry, politicians and academics. One manifestation of this interest is the large number of quality-related articles appearing in a wide variety of academic, practitioner and general interest publications. TQM implies good decisions and correct action by managers in creating an environment that empowers workers and fosters the continuous improvement of all organizational processes in and among various functional areas. TQM is universally accepted as one of the most understood change management programmes and is one of the strategies for confronting the global competitive challenge facing both manufacturing and service industries. Numerous frameworks have been proposed for TQM implementation elements and various studies have also been carried out to identify elements for the successful manifestation of TQM in an organization. TQM was frequently cited as a strategic option for achieving competitive advantage in the 1990s, yet it had received little attention in the evolving enterprise environments of integrated SCM and e-commerce. SCM has generally been associated with modern materials management, advanced information technologies, rapid and responsive logistics service, effective supplier management, and increasingly with customer relationship management (Fawcett and Magnan, 2002). Taveira et al. (2003) examined hypotheses regarding influence of TQM on work environment and concluded that most TQM elements were significantly related to work environment scales viz. supervisor support, task orientation, task clarity and innovation. Testa et al. (2003) did regression analysis to suggest national and organizational cultural congruence has positive effect on job satisfaction. Specific dimensions of human factors have been covered by various other studies (Legge, 1995). However, the authors have not come across any literature on mathematical modeling of different human aspects in TQM leading to single numerical index. Total quality management (TQM) has received worldwide acceptability and recognition. The core values of TQM, integrating all the interacting components in an organization, are applicable to any size of organization – large or small, any type of organization – manufacturing or service, private or public. However, preparation for realizing the fruits of TQM is challenging, since it is a multifaceted and complex phenomenon involving every facility and every individual at all levels.

2.2. Effective Factors in TQM implementation

Based on the previous literature review, we focus on four main aspects including.From these main aspects, 16 influential factors for the TQM implementation. The classification of those main aspects and their influential factors are shown in Table 1.

Table 1. Influential factors for TQM implementation

Main aspect	Influential factors	Reference
Management factors	Top management support	Saraph et al. (1989), Flynn et al. (1994), Ahire et al.(1996), Zeitz et al.(1997), Tamimi (1995), Motwani (2001), Antony et al. (2002), Zhang (2000), Quazi et al. (1998), Gaddene and Sharma (2009), Koh and Low (2010)
	Supplier quality management	Saraph et al. (1989), Flynn et al. (1994), Ahire et al.(1996), Black and Porter (1996), Powell (1995), Das et al. (2008), Koh and Low (2010)
	Training	Saraph et al. (1989), Flynn et al. (1994), Powell (1995), Zhang (2000), Quazi et al. (1998), Gaddene and Sharma (2009), Black and Porter (1996)
	Employee participation	Saraph et al. (1989), Ahire et al.(1996), Zeitz et al.(1997), Black and Porter (1996), Quazi et al. (1998), Rao et al. (1999), Das et al. (2008)
	Organizational performance	Ngai and Cheng (1997) Black and Porter (1996), Flynn et al. (1994), Antony et al. (2002), Koh and Low (2010)
	Planning, policies	Ahire et al.(1996), Black and Porter (1996), (Zink and Voss, 1998), Amar and Zain

Organizational factors	and strategies	(2002), (Tan and Khoo, 2002)
	teamwork	Saraph et al. (1989), Ahire et al.(1996), Zeitz et al.(1997), (Zink and Voss, 1998), (Tan and Khoo, 2002)
	Organizational Structure	Quazi et al. (1998), Gaddene and Sharma (2009), Black and Porter (1996), Rao et al. (1999), Antony et al. (2002)
Process factors	Quality management process	Black and Porter (1996), Powell (1995), Flynn et al. (1994), Ahire et al.(1996), Quazi et al. (1998), Rao et al. (1999), Zeitz et al.(1997), Tamimi (1995), Das et al. (2008), Koh and Low (2010)
	Product/service design	Saraph et al. (1989), Flynn et al. (1994), Ahire et al.(1996), Black and Porter (1996), Rao et al. (1999), Motwani (2001), Zhang (2000)
	Customer Satisfaction	Saraph et al. (1989), Ahire et al.(1996), Black and Porter (1996), Antony et al. (2002), Zhang (2000)
	benchmarking	Saraph et al. (1989), Ahire et al.(1996), Rao et al. (1999), Motwani (2001), Gaddene and Sharma (2009), Das et al. (2008)
Quality factors	Role of the quality department	Saraph et al. (1989), Ahire et al.(1996), Black and Porter (1996), Rao et al. (1999), Antony et al. (2002)
	Continuous Improvement	Saraph et al. (1989), Ahire et al.(1996), Motwani (2001), Rao et al. (1999), Gaddene and Sharma (2009), Das et al. (2008)
	Quality data and reporting	Saraph et al. (1989), Flynn et al. (1994), Ahire et al.(1996), Zeitz et al.(1997), Black and Porter (1996), Powell (1995), Antony et al. (2002), Koh and Low (2010)
	Quality Culture	Black and Porter (1996), Amar and Zain (2002), Ngai and Cheng (1997)

2.3. Analytic hierarchy process

TheAHP was developed by Thomas L. Saatyat the Wharton School of Business in 1970s. It is an effective decision-making technique based on multi-criteria decision-making methodology. The AHP is perhaps, the most widely used decision-making approach in the world and its validity is based on the many thousands of actual applications in which the AHP results were accepted and used by the cognizant decision makers (Saaty, 1994a).AHP is a method of breaking down a complex, unstructured situation into its component parts, arranging these parts or judgments on the relative importance of each variable and synthesizing the judgments to determine which variables have the highest priority and should be acted upon to influence the outcome of the situation (Saaty, 1990). It is a measurement theory that can deal with quantitative and qualitative criteria (Vargas, 1990). AHP is a systematic procedure for representing the constituent elements of any problem hierarchically (Saaty and Kearns, 1985) and the hierarchical structure will normally have three to four levels. The Level 1 reflects the overall goal or focus of the decision, Level 2 reflects the criteria for the decision, Level 3 contains sub-criteria if any and Level 4 contains the decision choices or alternatives. The proposed framework of this paper involves the following five major steps and these steps are based on Min and Min (1996, 1997), Min et al. (2002), and Chow and Luk (2005):

(1) Decide upon the list of criteria and container carriers for the benchmarking exercise and structure the problem into a hierarchical form.

(2) Make pairwise comparisons among criteria, estimate their relative priorities and check the consistency of pairwise comparison judgments.

(3) Make pairwise comparisons among the container carriers, determine their local priorities and check the consistency of pairwise comparison judgments.

(4) Synthesize the relative priorities of criteria with the local priorities of container carriers to find out the benchmark and conduct sensitivity analysis.

(5) Measure the competitive gaps.

Pairwise comparisons are basic to the AHP methodology. For pairwise comparisons, this paper uses the nine-point scale developed by Saaty (1980) and it is shown in Table 2.

In the above original AHP scale, weak was subsequently changed to moderate and absolute changed to extreme. The intermediate values 2, 4, 6, and 8 are defined as weak or slight, moderate plus, strong plus, and very-very strong, respectively. When activities are very close, a decimal is added to the scale values to show their differences as appropriate, e.g. 1.1, 1.9, 2.1, 2.9, etc. According to Saaty (2008), assigning small decimals is a better alternative way to compare two close activities with other widely contrasting ones, favoring the larger one a little over the smaller one when using the one to nine values. For example, if the service quality of container carrier A is measured as 2.4 over B, this will mean the service quality of A is “moderate plus” slightly or weakly more than B. However, it should be noted that small changes in judgment lead to small changes in the derived priorities (Wilkinson, 1965, as cited in Saaty, 2008). This original AHP scale is used in the present paper because it has been validated for effectiveness, not only in many applications by a number of people,

but also through theoretical comparisons with a large number of other scales (Saaty, 1990). Saaty used a nine-point scale in AHP because he agreed to the findings of Miller, who had reported that there is an upper limit on our capacity to process information on simultaneously interacting elements with reliable accuracy and with validity and this limit is seven plus or minus two elements (Kannan, 2010).

Table 2. Pairwise comparison scale

Intensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Weak importance of one over another	Experience and judgment slightly favor one activity over another
5	Essential or strong importance	Experience and judgment strongly favor one activity over another
7	Very strong or demonstrated importance	An activity is very strongly favored over another. Its dominance is demonstrated in practice
9	Absolute importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values between adjacent scale values	For use when compromise is needed
Reciprocals of above non-zero numbers	If the activity i has one of the above non-zero numbers assigned to it when compared with activity j, then j has the reciprocal value when compared to i	A reasonable assumption

Source: Saaty (1980)

2.4. DEMATEL method

The procedures of the DEMATEL method (Fontela & Gabus, 1976) are discussed below.

Step 1: *Generating the direct-relation matrix.*

We use five scales for measuring the relationship among different criteria: 0 (no influence), 1 (very low influence), 2 (low influence), 3 (high influence), and 4 (very high influence). Next, decision makers prepare sets of the pair-wise comparisons in terms of effects and direction between criteria. Then the initial data can be obtained as the direct-relation matrix which is an $n \times n$ matrix T where each element of a_{ij} is denoted as the degree in which the criterion i affects the criterion j.

Step 2: *Normalizing the direct-relation matrix.* Normalization is performed using the following,

$$K = \frac{1}{max_{1 \le i \le n} \sum_{j=1}^{n} a_{ij}} \; i, j = 1,2, \dots, n \qquad (1)$$

$$S = K.T \qquad (2)$$

Step 3: *Attaining the total-relation matrix.* The total relation matrix M can be acquired by using Eq. (3), where I is denoted as the identity matrix

$$M = X(I - X)^{-1} \qquad (3)$$

Step 4: *Producing a causal diagram.* The sum of rows and the sum of columns are separately denoted as vector D and vector R through Eqs. (4-6). Then, the horizontal axis vector ($D + R$) named ''Prominence'' is made by adding D to R, which reveals the relative importance of each criterion. Similarly, the vertical axis ($D - R$) named ''Relation'' is made by subtracting R from D, which may divide criteria into a cause and effect groups. Generally, when ($D - R$) is positive, the criterion belongs to the cause group and when the ($D - R$) is negative, the criterion represents the effect group. Therefore, the causal diagram can be obtained by mapping the dataset of the ($D + R$, $D - R$), providing some insight for making decisions.

$$M = [m_{ij}]_{n \times n}, \quad i, j = 1,2, \dots, n \qquad (4)$$

$$D = \left[\sum_{j=1}^{n} m_{ij}\right]_{n \times 1} = [t_{i.}]_{n \times 1} \qquad (5)$$

$$R = \left[\sum_{i=1}^{n} m_{ij}\right]_{1 \times n} = [t_{j.}]_{1 \times n} \qquad (6)$$

where D and R denote the sum of rows and the sum of columns, respectively. Finally, a causal and effect graph can be acquired by mapping the dataset of (D + R, D - R), where the horizontal axis (D + R) is made by adding D to R, and the vertical axis (D - R) is made by subtracting R from D.

3. Methodology

In this study were used two types of questionnaires, AHP questionnaire and DEMATEL questionnaire. After identified the hierarchical decision tree, In order to gather these data, AHP questionnaire is designed and distributed among 15 experts in Golrang Company. The second questionnaire (DEMATEL questionnaire) contained a table consisting of 16 rows and columns, according to the research questions have been developed. Factors considered in the questionnaire are effective factor on implementation of TQM. We use five scales for measuring the relationship among different criteria: 0 (no influence), 1 (very low influence), 2 (low influence), 3 (high influence), and 4 (very high influence). Next, decision makers prepare sets of the pair-wise comparisons in terms of effects and direction between criteria.

4. Results and Findings

4.1. AHP Results

Table 3 show rank the Effective Factors in TQM implementation by AHP. Among all the factors in the implementation of quality management systems, management factor with total weight (0.326) is most important and highest rank. Also consider the following factors, factors such as Top management support with total weight (0.114), Training with total weight (0.095), teamwork with total weight (0.086), Employee participation with total weight (0.084), Continuous Improvement with total weight (0.078), Role of the quality department with total weight (0.073), are most important factors.

Table 3: ranking the Effective Factors in TQM implementation by AHP

main criteria	Weight of the main criteria	sub-criteria	Weigh criteria in sub group	total weight	rank
Management factors	0.326	Top management support	0.349	0.114	1
		Supplier quality management	0.102	0.033	14
		Training	0.292	0.095	2
		Employee participation	0.257	0.084	4
Organizational factors	0.224	Organizational performance	0.172	0.038	13
		Planning, policies and strategies	0.314	0.070	7
		teamwork	0.383	0.086	3
		Organizational Structure	0.131	0.030	16
Process factors	0.172	Quality management process	0.186	0.032	15
		Product/service design	0.261	0.045	12
		Customer Satisfaction	0.286	0.050	10
		benchmarking	0.267	0.046	11
Quality factors	0.278	Role of the quality department	0.263	0.073	6
		Continuous Improvement	0.282	0.078	5
		Quality data and reporting	0.218	0.061	9
		Quality Culture	0.237	0.066	8

4.2. DEMATEL Results

Table 4 show Final results of the intensity of effects of Factors by DEMATEL.The results show that the top management support has the greatest impact on other factors. Indeed, among all the factors in the implementation of quality management systems, Top management support is the most influential factor.After this factor, factors such as Quality management process, teamwork and Continuous Improvement Have the highest impact. The results also show that among all the factors in the implementation, factors such as Organizational performance, Supplier quality management, Product/service design and Customer Satisfaction are the most affected.

Table 4: Final results of The intensity of effects of Factors by DEMATEL

Total row **(D)**		Total column **(R)**		Total Row and Column **(D+R)**		Difference of Row and Column **(D-R)**	
Top management support	5.22	Supplier quality management	4.85	Organizational Structure	9.16	Top management support	1.31
Quality management process	4.93	Organizational performance	4.64	Top management support	9.13	Quality management process	1.24
Continuous Improvement	4.89	Product/service design	4.59	benchmarking	9.06	teamwork	1.12
teamwork	4.88	benchmarking	4.45	Continuous Improvement	9.02	Continuous Improvement	0.76
Role of the quality department	4.85	Customer Satisfaction	4.38	Role of the quality department	8.99	Role of the quality department	0.71
Organizational Structure	4.83	Quality data and reporting	4.37	Quality data and reporting	8.7	Organizational Structure	0.5
benchmarking	4.61	Planning, policies and strategies	4.33	teamwork	8.64	Training	0.21
Training	4.37	Organizational Structure	4.33	Quality management process	8.62	benchmarking	0.16
Quality data and reporting	4.33	Training	4.16	Training	8.53	Employee participation	0.07
Employee participation	4.16	Role of the quality department	4.14	Supplier quality management	8.31	Quality data and reporting	-0.04
Quality Culture	3.77	Continuous Improvement	4.13	Employee participation	8.25	Quality Culture	-0.18
Planning, policies and strategies	3.76	Employee participation	4.09	Planning, policies and strategies	8.09	Planning, policies and strategies	-0.57
Supplier quality management	3.46	Quality Culture	3.95	Product/service design	7.96	Customer Satisfaction	-1.08
Product/service design	3.37	Top management support	3.91	Quality Culture	7.72	Product/service design	-1.22
Customer Satisfaction	3.3	teamwork	3.76	Customer Satisfaction	7.68	Supplier quality management	-1.39
Organizational performance	3.04	Quality management process	3.69	Organizational performance	7.68	Organizational performance	-1.6

5. Conclusion

The purpose of this paper is Identifying and Prioritization Effective Factors in TQM implementation Using AHP and DEMATEL Methods. In this study were used two types of questionnaires, AHP questionnaire and DEMATEL questionnaire. After identified the hierarchical decision tree, In order to gather these data, AHP questionnaire is designed and distributed among 15 experts in Golrang Company. The study result shows that the main factors in TQM implementation are Management factors and quality factors (by AHP approach). The degree of visibility and support that management takes in implementing a total quality environment is critical to the success of TQM implementation. The literature review uncovered four distinctive ways that management can support TQM implementation: allocating budgets and resources; control through visibility; monitoring progress; and planning for change. A company must embrace strong acceptance and maintenance of a total quality measurement and benchmarking plan. Most authors endorse a ``zero defect'' and a ``do it right the first time'' attitude towards the quality program. Quality programs should measure the percentage or the number of parts that deviate from the acceptable in order to prevent the recurrence of a defect. Effective factors in TQM implementation are Top management support and Quality management process (by DEMATEL approach). Ahire et al. (1996) identified, validated, and tested 12 constructs of integrated quality management through an empirical survey of 371 manufacturing firms. Zeitz et al. (1997) developed a survey instrument designed to measure TQM and supporting organizational culture. In this study, 13 priori dimensions of TQM and ten priori dimensions of organizational culture or climate were operationalized in a 113-item survey designed to measure the level of culture and TQM as experienced by individual members. Black and Porter (1996) developed a questionnaire based on a series of items from the Baldrige model and established literature. A 39-items survey was developed and sent to over 200 managers drawn from a target sample of members of the European Foundation for Quality Management. Easton and Jarrell (1998) examined the impact of TQM on the performance of 108 firms that began TQM implementation between 1981 and 1991. They measured the impact of TQM by comparing each firm's performance to a control benchmark. The findings indicate that performance, measured by accounting variables and stock returns, is improved for the firms adopting TQM.

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