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Prioritising the TQM Enablers and IT Resources in the ICT Industry: An AHP Approach

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***Abstract*—**Total Quality Management (TQM) is a managerial approach that improves the competitiveness of the industry, meanwhile Information technology (IT) was introduced with TQM for handling the technical issues which is supported by quality experts for fulfilling the customers' requirement. Present paper aims to utilise AHP (Analytic Hierarchy Process) methodology to priorities and rank the hierarchy levels of TQM enablers and IT resource together for its successful implementation in the Information and Communication Technology (ICT) industry. A total of 17 TQM enablers (nine) and IT resources (eight) were identified and partitioned into 3 categories and were prioritised by AHP approach. The finding indicates that the 17 sub-criteria can be grouped into three main categories namely organizing, tools and techniques, and culture and people. Further, out of 17 sub-criteria, three sub-criteria: top management commitment and support, total employee involvement, and continuous improvement got highest priority whereas three sub-criteria such as structural equation modelling, culture change, and customer satisfaction got lowest priority. The result suggests a hierarchy model for ICT industry to prioritise the enablers and resources as well as to improve the TQM and IT performance in the ICT industry. This paper has some managerial implication which suggests the managers of ICT industry to implement TQM and IT together in their organizations to get maximum benefits and how to utilize available resources. At the end, conclusions, limitation, future scope of the study are presented.

***Keywords*—**Analytic Hierarchy Process, Information Technology, Information and Communication Technology, Prioritization, Total Quality Management.

I. Introduction

DURING past two decades quality has a major role in productivity and it is significantly contributing to improve the market share and to compete the global market. As competition increases and changes occur in the industries we need to have better understand the quality. Top management should concern quality at every competitive level of the industry to achieve high performance levels of products. As the competitiveness, increase in the market long time survival of industry becomes hard, then we choose the total quality management (TQM) strategy to stay in the market [1]. TQM proves itself a best approach for improving the quality of products [2]. In order to improve productivity and organization quality has to consider technology and resources. TQM is an improvement tool for quality and business performance which is enhances the customer satisfaction. According to [3], TQM aims to achieve the effectiveness of the system such as design, planning, production, customer satisfaction and quality tools and techniques involvement. TQM has potential not only to increase competitiveness, but also to improve organizational effectiveness and produce more satisfied customers. As global market competition is increased IT (Information Technology) was introduced by researchers to produce a better product than competition becomes a great challenge. IT is widely accepted as essential to organizational effectiveness, also IT work as an enabler of the structural adjustment of the organization to TQM changes [4].

TQM and IT is the combination of techniques and strategies in order to obtain the business excellence quality. Improvement of quality suggest in to improvement in productivity by reducing errors, costs, rework and delay. TQM acting like facilitator which adapt principles and practices while IT provides suitable resources to successfully implement the TQM program. Combination of enablers and resources has given birth to a new requirement, which is to successfully combine TQM and IT in any organization [5]. Brah and Lim [6] found that TQM and IT plays an important role in improving performance of quality management. There is lack of study on TQM and IT together in the ICT industry [7]. This study investigates those factors of TQM and IT can be used for enhancing productivity and quality. To improve the productivity and quality of organizations need resources and technology. Find out the influencing factors and boost them to concern the quality improvement program. This study has attempted to identify the factors of criteria and sub-criteria for these organizations to implement TQM-IT using AHP approach. An identified factor of TQM & IT determines and correlated between them and ranks them by AHP method for efficient productivity.

This paper is organized as follows. TQM enabler and IT resources factors were divided into three different categories which are explored in the next section. Then research objective and methodology were carried out. An AHP approach was used to identify the relative importance of factors in the subsequent section. In the next section result and analysis were presented followed by discussion, conclusion, limitation and future scope of the study.

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II. Criteria of TQM Enablers and IT Resources

Implementation of TQM needs categorization of TQM and IT factors into three different criteria. A list of critical factors consolidated from literature review on TQM implementation. This research identified 17 TQM and IT factors and they were divided into factors namely: organizing (OG), culture and people (CP) and tools & techniques (TT). The factor categorization was done with the help of discussion with the experts and academicians in the quality area. Categorization of TQM enablers and IT resources was done by [8], [9].

A. Organizing

This factor involves organization in strategic planning. Strategic factors are those factors that are important and critical for achieving business excellence [10]. These factors play dominant role in the successful implementation of TQM program [11]. There are four factors of TQM under this category, organizing require top management commitment & support gives full commitment to quality settings which organize and synergize people's activities to achieve common goal of the organization [12]. In order to communicate quality strategy across the organization, top management should create an organizational that focuses on continuous improvement.

Second, having continuous improvement helps in eliminating lead times in delivery, reducing errors thereby continuously improving business performance and reducing all non-value adding activities to a minimum [13].

Third, continuous training is one of the keys of any meaningful quality improvement programme. Goh [14] has investigated that CT programs are important as these could assist to solve problems such as lack of motivation, absorptive capability and retentive capacity. Therefore, a successful CT will definitely encourage the employees to have the sense of knowledge sharing.

Fourth factor is empowerment means assigning of responsibility with authority to the employees. Empowerment involves the employees in organization implies that every organizational member is participates in quality improvement process, decision making process, problem solving and directly or indirectly instrumental to the financial success of the organization [15].

B. Culture & People

The behavior and thoughts of people also reflects the shows the culture of the organization. Five factors are coming under in this categorization. Organization can enhance people's ability to solve problems and utilize opportunities with the effective employee involvement [16].

Also, total employee involvement develops both top down and bottom up communication channel, providing a mechanism for employees to voice their concerns or suggestion on quality issues and direct participation in the decision making process [17].

Second factor is customer satisfaction, would lead to improve quality irrespective of the countries and their culture [18]. Satisfied customer were maintained the culture of the business environment. Next factor is culture change focus on the continuous improvement of the ICT industry. Changing of organizational culture towards quality can be arranged into technological aspects and intangible aspects [19].

Culture shows the organizational behavior, it creates an environment where people can help each other and achieve their goals [20]. Democratic management style is one of management style where major decisions are agreed upon by the majority. In other words in this management style has opportunity to contributes their ideas to make decision in their decision. It covers organizational goal, growth, culture and satisfaction of the customer [8], [21].

Fourth factor, teamwork is basic needs in all organization which makes work more flexible and develops trust amongst member [22].

C. Tools & Techniques

TQM holds a wide range of approaches, systems and tools and techniques. Tools and Techniques are also critical factor and have their major role in quality management. This category brings quality management to the system analysis. There are eight IT resources in this category. First IT resource is electronic data interchange is one of the most widely used technologies among trading partners and EDI has been used in managing the information flow between customers and suppliers. EDI contributes to QDWM (Quality Data and Workforce Management) by collecting and communicating QP (Quality Product) and employee empowerment [23]. Another IT resources is computer –aided-design and computer-aided-manufacturing are widely used technologies in product design and manufacturing therefore one of the most appropriate technologies to understand the relationship between IT and Product Process Management (PPM) [23].

The second factor is ERP system is also an IT resource, which manages multiple areas of an organization including sales, production planning and scheduling, quality control and human resource management [24]. The next IT factor is computer-aided- process planning system automates all production planning aspects to serve as an interface between design and manufacturing [25]. Computer-aided-engineering systems are used to analyze the robustness and performance of components and assemblies. It can be a major provider of information to help support design teams in decision making. It is one the tool used to shorten the exploitation period of products [26].

Another resource is SPSS which is popularly used in statistical problems, it is useful tool for marketing research for questionnaire purpose. An internal consistency was measured by using to assess the reliability aspect of the survey instrument; therefore, SPSS is an important tool for implementing much functionality related to TQM implementation. Last factor of this category is structural equation modelling has been used to growing in business and technology including quality management [27]. By [28], SEM approach provides insight into current IT and TQM theory and practices on operational and quality performance.

III. Research Objective and Methodology

This paper has the following two fold objectives:

1) To categorize the TQM enablers and IT resources factors.
2) To rank the relative importance of TQM enabler and IT resources by using AHP.

This study is based on descriptive – survey means researcher has described the subject and survey instrument for collecting the without changing the condition of study. This study is divided into three phases.

A. Construct a Hierarchy Model for Implementing the TQM Enablers and IT Resources

AHP framework was developed by [29], [30] guidelines in Fig. 1. TQM enablers and IT resources was decomposed into the framework of hierarchical structure. The framework has three levels of hierarchy, level 1 shown the goal of problem and level 2 & 3 states that criteria and sub-criteria of the problem.

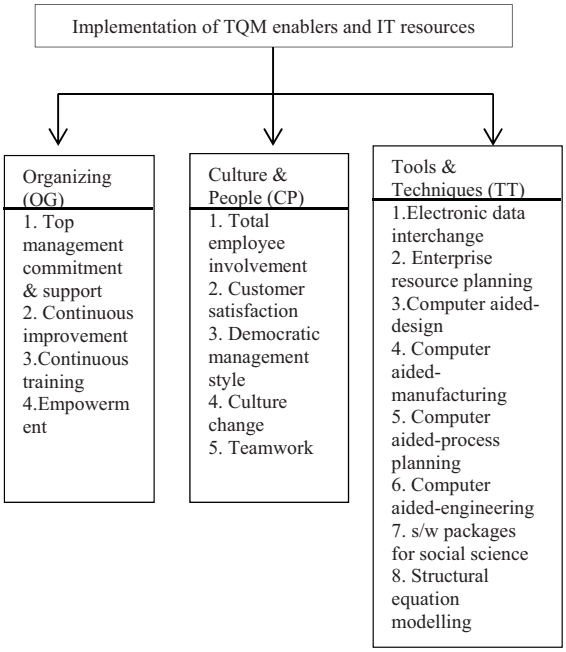

Fig. 1 Hierarchy model of TQM enabler and IT resource

B. Collecting and Measuring Data

This phase is concerned with the collection of information and data through the combined judgments of the individual experts from the ICT industry and academia. A group of 15 experts was invited for interview for evaluating the criteria and sub-criteria. Five experts from academia and ten experts invited from ICT industry (3 experts from Information technology, 2 from software development, 4 from telecommunication & 1 from BPO) having wide experience of the quality management.

C. Determine the Weights of Each Level of Criteria and Sub Criteria

Once the expert's information was collected, the next step is to determine the each level weight-age of criteria and sub-criteria. In order to determine the relative importance of criteria and sub-criteria, those pairwise comparison judgments were translated into the largest eigenvalue problem and then computed the highest priority weight of criteria and sub-criteria from Tables II, V, VIII XI. In the next step priority weights are divided into 'local weights' and 'global weights'.

IV. AHP: An Overview

AHP is developed by [29], [30], which is simplifying the complex and un-structured problems. It is designed to decomposed complex, multi-criteria problem into multiple levels of hierarchy which the top levels of hierarchy with the top level as the goal or objective, while the intermediate levels are the criteria and sub-criteria, and the lowest offers alternatives, forming a hierarchy structure [29, 30]. According to [31], AHP can accommodate both objectives and sub-objectives judgments of the evaluators involved in order to make a trade-off and to determine priorities among them. AHP prioritizes the relative importance of a list of criteria (critical factors and sub-factors) through pairwise comparisons amongst the factors by relevant experts using a nine-point scale. It is based on both predetermined measurement and expert judgments throughout the system which are calculated through pairwise comparison

Talib et al. [32] found that experts and decision makers are interviewed and pair-wise comparison judgments are applied to pairs of homogeneous criteria, eventually generating the overall priorities for ranking the alternatives [29]. The AHP method is extensively used in different are areas in different application. Chin et al. [8] investigates the critical factors and sub-factors that determine the adoption and implementation of TQM by using AHP. Singh [33] using AHP to prioritizes the factors for coordinated supply chain. Talib et al. [7] prioritized the 17 TQM practices in service industry with the AHP approach. An AHP approach was employed in a study to identify and examine the importance of the key success factors of strategic sourcing in the Hong Kong toy industry [34], [35]. Koilakuntla et al. [36] has attempted to develop organization specific factors and factor ratings by considering business specific key performance indicators (KPIs) along with weighted rating with the help of AHP. Chein and Barthorpe [37] explore the critical success factors for performance management of the Taiwanese Veterans Home by AHP. Lewis et al. [38] used AHP approach to determine the extent to which the criteria of TQM are achieved in ISO 9001 certified small-and-medium sized enterprise (SMEs) in Trinidad and Tobago (T&T). Sagar and Tomar [39] are used AHP to ranking the identified critical success factors of TQM in favour of Indian manufacturing industry for improving product process and quality.

Some of the applications are discussed in the next section, and from the literature review it was found priority and ranking of factors.

V. AHP Methodology

AHP is a popular technique for solving the problems:

- Calculate pair-wise comparison matrices for each level of criteria and sub criteria by using scale measurement shown in Table I,
- Calculate the priority weight of criteria and sub criteria,
- Calculate the consistency ratio CR (CI/RI),
- Calculate the max eigen vector λ_{max},
- Calculate the consistency index CI,
- Selecting consistency ratio to check whether the decision makers comparisons were consistent or not.

Finally, global weight is find out with the help of priority weight to the ranking of the factors Global weight of all factors are presented in Tables IX, X. The global weight helps to author to rank all the factors from most effective to least effective with respect to TQM and IT implementation in the ICT industry. In this study author choose 17 factors and grouped them into three criteria.

TABLE I
PAIR-WISE SCALE FOR RELATIVE COMPARISON

Scale	Judgment of preference
1	Equal importance
3	Moderate importance of one over the other
5	Essential or strong importance
7	Very strong or demonstrated importance
9	Extreme or absolute importance
2,4,6,8	Intermediate values between the two adjacent judgment

TABLE II
RATIO RANDOM NUMBER INDEX

Size of matrix	1	2	3	4	5	6	7	8	9	10
Random index (RI)	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.51

TABLE III
PAIR-WISE COMPARISON OF CATEGORISED THREE CRITERIA OF TQM ENABLER AND IT RESOURCES

Criteria	Organizing	Culture & People	Tools & Techniques
Organizing	1	3	7
Culture & People	1/3	1	3
Tools & Techniques	1/7	1/3	1
Sum	31/21	13/3	11

TABLE IV
SYNTHESIZED MATRIX OF CRITERIA

Criteria	Organizing	Culture & People	Tools & Techniques
Organizing	21/31	9/13	7/11
Culture & People	7/31	3/13	3/11
Tools & Techniques	3/31	1/3	1/11
Sum	1	1	1

TABLE V
PRIORITY WEIGHT

Criteria	Priority weight
Organizing	0.699
Culture & People	0.244
Tools & Techniques	0.089
Sum	1

TABLE VI
CONSISTENCY RATIO

Factor	δ	Eigenvector (λ)
Organizing	2.024	3.025
Culture & People	0.734	3.008
Tools & Techniques	0.266	2.989
		$\lambda_{max} = 3.025$

CI= 0.012, RI=0.58, CR=0.0219 (n=3)

TABLE VII
PAIR-WISE COMPARISON OF ORGANIZING SUB-CRITERIA

Factors	Top management commitment & support	Empowerment	Continuous training	Continuous Improvement
Top management commitment & support	1	1	3	7
Empowerment	1	1	2	4
Continuous training	1/3	½	1	3
Continuous Improvement	1/7	¼	1/3	1
Sum	52/21	11/4	19/3	15

λ_{max}=4.045,CI=0.015, RI=0.90, CR=0.016 (n=4)

TABLE VIII
PAIR-WISE MATRIX OF CULTURE & PEOPLE SUB-CRITERIA

Factors	Total employee involvement	Customer satisfaction	Democratic management style	Culture change	Teamwork
Total employee involvement	1	3	5	5	5
Customer satisfaction	1/3	1	5	3	3
Democratic management style	1/5	1/5	1	7	5
Culture change	1/3	1/3	3	1	3
Teamwork	1/3	1/3	3	3	1
Sum	33/15	73/15	17	31/3	23/3

λ_{max}=5.356, CI=0.089, RI=1.12, CR= 0.079 (n=5)

TABLE IX
PAIR-WISE MATRIX OF TOOLS & TECHNIQUES SUB-CRITERIA

Factors	Electronic data interchange	Enterprise resource planning	Computer aided design	Computer aided manufacturing	Computer aided process planning	Computer aided engineering	Software packages for social science	Structural equation modelling
Electronic data interchange	1	1/3	3	3	2	2	4	4
Enterprise resource planning	3	1	3	3	3	3	3	3
Computer aided design	1/3	1/3	1	3	3	2	2	2
Computer aided manufacturing	1/3	1/3	1/3	1	3	3	2	2
Computer aided process planning	½	1/3	1/3	1/3	1	1/3	2	2
Computer aided engineering	½	1/3	1/2	1/3	3	1	2	2
Software packages for social science	¼	1/3	1/2	½	1/2	1/2	1	3
Structural equation modeling	¼	1/3	1/2	½	1/2	1/2	1/3	1
Sum	37/6	10	55/6	70/6	16	37/3	49/3	19

λ_{max}= 8.884, CI= 0.127, RI=1.41, CR=0.088 (n=8)

TABLE X
RANK OF CRITERIA'S (TQM ENABLERS & IT RESOURCES)

Criteria	Local weights	Global weights	Ranking
Organizing	0.699	0.699	1
Culture & People	0.244	0.244	2
Tools & Techniques	0.089	0.089	3

TABLE XI
RANK OF SUB-CRITERIA'S (TQM ENABLERS & IT RESOURCES)

Categorised sub-criteria	Local weights	Global weights	Ranking
Top management commitment & support	0.427	0.299	**1**
Empowerment	0.338	0.237	**2**
Continuous training	0.169	0.119	**3**
Continuous improvement	0.069	0.049	**6**
Total employee involvement	0.269	0.066	**5**
Customer satisfaction	0.422	0.103	**4**
Democratic management style	0.053	0.013	**11**
Culture change	0.120	0.030	**8**
Teamwork	0.163	0.040	**7**
Electronic data interchange	0.204	0.019	**10**
Enterprise resource planning	0.275	0.025	**9**
Computer aided design	0.142	0.013	**12**
Computer aided manufacturing	0.114	0.011	**13**
Computer aided process planning	0.089	0.008	**14**
Computer aided engineering	0.070	0.007	**15**
Software packages for social science	0.062	0.006	**16**
Structural equation modelling	0.047	0.005	**17**

VI. RESULT AND ANALYSIS

Tables X & XI show the local weights and global weights of three criteria and 17 factors include nine TQM enablers and eight IT resources that were analysed by AHP approach. The researchers consider "organizing criteria" are the most important criteria followed by "tools & techniques criteria" and "culture & people" at the hierarchical level 2. The local weight and global weight (organizing=0.699, culture & people =0.244, tools & techniques = 0.089) will be same at hierarchy level 3.

At hierarchy level 3, evaluators considered local weights of sub-criteria 'top management commitment & support' (0.427) as the most important sub-criteria followed by 'empowerment' (0.338), 'continuous training' (0.169), and 'continuous improvement' (0.069).

For 'culture & people' criteria have five TQM enablers namely 'total employee involvement' (0.269), 'customer satisfaction' (0.407), 'democratic management style' (0.053), 'culture change' (0.120) and 'teamwork' (0.163).

For the next 'tools & techniques' criteria have eight IT resources named as 'electronic data interchange' (0.204), 'enterprise resources planning' (0.275), 'computer-aided design' (0.142), computer-aided manufacturing' (0.114), 'computer- aided process planning' (0.089), 'computer-aided

engineering' (0.070), 'software packages for social science' (0.062) and 'structural equation modelling' (0.047).

From Table XI shown the global weight of 'top management commitment & support' (0.299) is most important factor among the all factors, which is followed by 'empowerment' (0.237), 'continuous training' (0.119) and 'continuous improvement' (0.049).

Similarly, global weights of "culture & people' sub-criteria are 'total employee involvement' (0.066), 'customer satisfaction' (0.103), 'democratic management style' (0.013), 'culture change' (0.030), and 'teamwork' (0.040).

The global weights of 'tools & techniques' sub-criteria are 'electronic data interchange' (0.019), 'enterprise resources planning' (0.025), 'computer-aided design' (0.013), 'computer-aided manufacturing' (0.011), 'computer- aided process planning' (0.008), 'computer-aided engineering' (0.007), 'software packages for social science' (0.006) and 'structural equation modelling' (0.005).

VII. Discussion

With the help of expert discussion, nine TQM enablers and eight IT resources were identified and generated into three categories. These three categories named as 'organizing', 'culture & people' and tools & techniques'. The proposed AHP model can be also used to compare level of coordination in factor in the quality management. The study further identifies the priority ranking of the categorised criteria and sub-criteria. Organizing criteria has the greatest priority followed by 'tools & techniques criteria' and 'culture & people criteria'. Thus, the ICT industry should give most priority the organizing criteria. Organizing criteria requires sub-criteria 'top management commitment & support', 'empowerment', 'continuous training' and 'continuous improvement', function as vehicle to integrate quality requirements with business activities of ICT industry. So, without these factors TQM and IT cannot be implemented effectively and successfully in the industry.

The 'culture & people' are responsible for organizational performance and are concerned with the effectiveness of TQM & IT. TQM itself is a culture that supports customer satisfaction through employee involvement, teamwork, by changing culture and democratic management style. The behaviour and thoughts of people reflects the culture. Existing culture can be fad-up due to increasing customer demands, so it is necessary to understand what existing culture is and how it affects the TQM program. The changes in culture and people should be planned and carried out in consistent and progressive manner.

Finally, the third criteria Tools & techniques criteria technically supporting managers to provide the training and implementation support the training and implementation support necessary. For example are 'electronic data interchange', 'enterprise resources planning', 'computer-aided design', computer-aided manufacturing', 'computer- aided process planning', 'computer-aided engineering', 'software packages for social science' and 'structural equation modelling' are effectively used to identify a unique implementation plan detailed clarifying the order in particular tools and techniques should be used.

VIII. Conclusion

The purpose of this study is to investigate and categorise the TQM enablers and IT resources. The factors were prioritised on the basis of their relative importance for TQM and IT implementation in the ICT industry. Prioritization of current factors can be re-allocate by applicable resource for successfully improve the TQM and IT program together.

Implementation of TQM and IT requires through organizational performance and structure, tools & techniques and by cooperating with culture and behaviour of people. The priority of factors was ranked by experts and academia. It appears logically from the result 'top management commitment & support', 'total employee involvement' and 'continuous improvement' were the three most important sub-criteria found in the study of the TQM & IT implementation in the ICT industry. After implementing the selected factors, experts can review and evaluate of other remaining factors. The factors identified from the study provided a practical guide for the organization to conduct cross-organizational process improvement for quality.

In this research 17 factors were identified from previous study by [40, 41] and discussion with the experts of the ICT industry. Then factors were divided into three categories each containing numbers of factors for example organizing criteria (4 TQM enablers), culture & change criteria (5 TQM enablers) and tools & techniques (8 IT resources).

It is analysed from the tables top management commitment & support have scored the highest priority weight because the prime principle for running an organization must be enforced by the top managers and the employee must follow the culture and practical direction given by leaders. Top management is the major tent of TQM and IT which is responsible for creating and supporting ICT industry climate and culture. Also top management develops the psychology of going work in the organization [42].

Empowerment scored the second highest place in this study, employees contributes in decision making during its transformation from technology oriented company to customer focus found company. It is a managerial philosophy must apparently show in all activities in the industry. Employee involvement contributes in decision making decision making during its transformation from technology oriented company to customer focus found company [43]. Continuous training placed at third place, it is one of any meaningful quality improvement programme. Employees will understand the objective of quality only when they are equipped with quality concepts and tools [44].

The fourth scored weight is customer satisfaction is considered to be the key success factor for a profit oriented organization as it affects companies, market share and customer relations. Customer satisfaction is the one of major factor of organization, where surpass their competitors by addressing the customer needs and demands effectively as

well as anticipate and respond to their evolving interest and wants [45]. It is consider from this study ICT industry should focus on the most important to less TQM and IT to effectively implement TQM and IT program. This study would gradually reduce employee resistance to change the successful business environment

This research is also not free from limitations, because the study relies on only 5experts from industry and 10 experts from academia from the same country. In further studies includes number of experts from the different area like, education, hospitality, tourism, transportation, healthcare extra. This study is conducted only in one country; it can be further expanded in different countries.

The managerial approach of this study will be very useful to decision makers in the ICT industry as a guideline for implementing of TQM enabler and IT resources and in evaluating the effectiveness of current factors of TQM and IT.

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