PERFORMANCE MEASUREMENT OF TQM USING INTEGRATED FUZZY-AHP

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ABSTRACT

Performance measurement is regarded as one of the most important and critical tasks in the course of any organization. Measuring performance is the assessment of the possible impact that a proposed plan or project may have on the organizational system, together consisting of the financial, non-financial and operational aspects. The aim of this paper is to propose a performance measurement methodology based on an integrated Fuzzy-AHP approach in the context of total quality management (TQM). In the proposed methodology the criteria weights are generated by a fuzzy-AHP procedure. The fuzzy set theory is a perfect means for modeling uncertainty or imprecision arising from human mental phenomena. The usage of fuzzy sets in describing uncertainties and vagueness in different critical success factors of TQM simplifies the complex structure of performance assessment.

KEYWORDS: Performance Measurement, TQM, Multicriteria, Fuzzy, AHP

Received: Jun 08, 2020; **Accepted:** Jun 28, 2020; **Published:** Sep 01, 2020; **Paper Id.:** IJMPERDJUN20201008

INTRODUCTION

Performance measurement often has to deal with latent variables which were difficult to identify and define also components that may involve both quantitative and qualitative factors. Performance measurement is a complex task not only because of its wide scope but also because of the wide range of attributes that bear on its assessment, Kumar, R. et al. (2019). In terms of scope, an assessment may cover subjective and vague decisions that may affect various interest groups or stakeholders each with their own demands and needs. In view of these difficulties, methods based on fuzzy logic may be quite useful in undertaking difficult assessment procedures. The fuzzy set theory was introduced by Zadeh (1965) to express the linguistic terms in decision-making process in order to resolve the vagueness, ambiguity and subjectivity of human judgment. A fuzzy method stands very helpful to tackle precisely with complex and ill-defined performance measurement decision making problems. Very few organizations categorized themselves as having fairly TQM-driven performance management system, they were quite positive – if not yet revealing conclusive evidence – of understanding the influence of system factors on individual performance in a quality-driven context, Soltani, E. et al. (2005). G. G. Dess et al. (1984) addressed in his research that research which incorporates organizational performance (OP) must address two basic issues: (1) selection of a conceptual framework from which to define OP and (2) identification of accurate, available measures that operationalize OP. In addition, collecting data and information to coordinate and support the procedure of taking action and making decisions throughout the organization is the reason for performance measurement (Van Schalkwyk, 1998).

The subsystems like Just-in-Time (JIT), Total Productivity System (TPS), Total Productive Maintenance (TPM), Supply Chain Management (SCM), Lean Manufacturing (LM) System and many more were incorporated to the organizational system as per their fit to achieve the benchmarked performance or the targeted level of

performance. Vanichchinchai, A., and Igel, B. (2011) mentioned that to achieve JIT delivery, quality of the whole internal operations as well as that of the external partners must be assured. Scannell et al. (2000) found that JIT purchasing significantly associated with flexibility, conformance to specification and low production cost performance. Total Quality Management (TQM) is one of them most comprehensive management approach to ensure the higher levels of performance of the organization. TQM is not limited only to ensure the quality of products but it is equally important to vigil the performance of organization and also covers wider aspects of quality product and services. British Standard Institution defines; TQM consists of a “management philosophy and company practices which aim to harness the human and material resources of a corporation within the best way to achieve the objectives of the organization”. Definition of TQM by Feigenbaum’s (1988) encompasses every aspect of the TQM cycle including, customer focus, process planning, process management, and process improvement. Feigenbaum’s (1988) states that “a total quality system is defined as one which embraces the whole cycle of customer satisfaction from the interpretation of his requirements prior to the ordering stage, through to the supply of a product or service at an economical price and on to his perception of the product after he has used it over an appropriate period of time”.

Instead of investigating the gap based on a specific theoretical view, this study is an exploratory and quantitative effort focused on the identification of sources of the gap. As objective of this study, an integrated fuzzy AHP methodology is proposed for Performance measurement of TQM system. In the proposed methodology, the weights of the assessment criteria are determined by a fuzzy AHP procedure. The rest of the paper is organized as follows: In Section 2, a literature review about multiple attribute performance measurement is briefly given. In the third section, an integrated fuzzy AHP methodology is presented. In Section 4, following the determination of the selection criteria and alternatives, the proposed methodology is applied to a industrial problem. Finally, in the last section, conclusions and suggestions for further study are given. In sum, this study provides useful insights to support the decision making for performance measurement of companies to make strategic and resource allocations for developing high quality products to improve operational performance.

LITERATURE REVIEW

Performance measurement is a critical factor for the effective management. This may stem back from the fact that without measuring something, it is difficult to improve it, Ismail Salaheldin, S. (2009) strongly recommended. Therefore, improving the organizational performance requires identifying and measuring the impact of TQM practices on it (Demirbag et al., 2006; Koh et al., 2007). Performance Measurement (PM) is the process of identifying, predicting, evaluating and mitigating the critical success factors and other relevant effects of development proposals prior to major decisions being taken. Measuring performance is an important practice for ensuring that the likely effects of new development on the organizational system are fully understood and taken into account before the development is allowed to proceed. Performance appraisal, on the other hand, is defined as, ‘a formal documented system for the periodic review of an individual’s performance’ (Moon, 1993, p. 8); or, ‘the process by which data are collected and reviewed about an individual employee’s past and current work behaviour and performance’ (Bratton and Gold, 1999). Performance Measurement enables organizational factors to be given due weight, along with financial, non-financial or operational factors, when planning applications are being considered. If properly carried out, it benefits all those involved in the planning process. For the production planning and other strategist with quality control responsibilities, performance

measurement provides a basis for better decision making. The fundamental objectives of any organization are to establish and maintain competitive advantage and ensure strong organizational performance (Eisenhardt et al., 1998).

Performance Measurement and TQM

TQM practices have been successful in increasing organisational performance is that TQM serves as a link between an organisation's business or corporate strategy and its performance. TQM creates a system of checks and balances to ensure that an organisation's business strategy is successful (Prajogo and Sohal, 2006), the same pair author in year 2004 provided a multidimensional view of TQM practices in determining organizations' quality and innovation performance. TQM use to improve organizational efficiency and their effectiveness as well as to create tools to better manage the quality of products and services for their long-term customers. Pfeffer and Sutton (2006), argue that TQM practices emphasise evidence-based management that concentrates on creating visible and measurable improvements to processes, rather than on vague estimations of customer or client approval. A study presented by Ahire et al. (1996) about an analysis on the comparison for the Quality management in TQM firm versus non-TQM firms. Firms are classified as: high performance TQM firms, low performance TQM firms, high performance non-TQM firms and low performance non-TQM firms. Major reasons behind the failure of TQM effort viz. lack of management commitment, unrealistic expectations and time-frame and cost of TQM implementation, under-reliance on statistical methods, and failure to develop and sustain a quality-oriented culture are reported by authors. Measuring critical success factors (CSF) of TQM is an essential precondition to control the implementation process and to increase the chances of success, stated Hietschold, N. et al. (2014). Because there is no consensus on certain factors or a holistic framework, so Salaheldin (2009) stated that finding and selecting adequate measurement instruments is a major challenge to companies. The CSFs of TQM can be used to gain a better understanding of the practices of quality management, to determinethe existing quality position of an organization, to assign responsibilities within an organization and to supervise quality and improvement programs (Motwani et al., 1994).

Multiple Attribute Performance Measurement

Multi-criteria decision-making (MCDM) methods enable the decision-makers handle uncertainty, complexity and conflicting objectives. MCDM problems usually require both tangible and intangible factors to be evaluated. The main problem for intangible criteria is that the values for such criteria are often imprecisely defined for the decision-makers, and the desired value for the criteria are usually defined in linguistic terms. It is difficult to express the character and significance of criteria exactly or clearly in crisp methods Chou T.Y et al. (2008). Decision making in performance measurement problems can be complex and multifaceted due to the inherent barriers, volatility, uncertainty, complexity and ambiguity factors also. Moreover, decisions in performance measurement may involve many different stakeholders with different priorities or objectives. Many theories and methods of performance for conducting an evaluation with different approach have been applied in various organizations. These approaches include Balanced Scorecard, total production analysis, regression analysis, ratio analysis, Delphi analysis, Analytic Hierarchical Process (AHP), Data Envelopment Analysis (DEA) and others. Each method has its own basic concept, aim, advantages and disadvantages (Dessler, 2000). Which one is chosen by management or decision makers for assessing performance depends on the status and type of the organization. However, all the successful enterprises have some common features, including a specific vision, positive actions, and an effective performance evaluation. Since Bellman and Zadeh (1970) developed the theory of decision behaviour in a fuzzy environment, various relevant models were developed, and have been applied to different fields such as control engineering, artificial intelligence, management science, and Multiple Criteria Decision Making

(MCDM) among others. The concept of combining the fuzzy theory and MCDM is referred to as fuzzy MCDM (FMCDM). Liou and Tzeng (2007) considered that the attributes (criteria) might exist as dependent characteristics when they used a fuzzy integral approach to integrate the performance ratings of dependent attributes. Yildirim et al. (2019) used fuzzy analytical hierarchy method to determine the weighting scores of indicators of Logistics Performance Index (LPI). It is strongly considered that LPI is accepted as an important indicator of logistical performance. The proposed model is to evaluate the LPI of the OECD (Organisation for Economic Cooperation and Development) countries within a specific time frame and compared with the existing LPI rankings. Through a managerial view Kayakutlu and Buyukozkan (2011) present an analytical framework to measure the performance factors for 3PL companies. The factors integrating the strategic and operational targets are evaluated within a framework based on four levels: performance targets, planning activities, logistics operations, and performance attributes of logistics operations. The ANP method is used to determine the most effective performance attributes. To evaluate the performance of third-party logistics (3PLs), P. Kumar et al. (2012) with the implication of an integrated model of fuzzy analytic hierarchy process (FAHP) and technique for order preference by similarity to ideal solution (TOPSIS) used. FAHP is used to assign the weight to criteria for 3PL rating in this paper. Presented work by Jiansheng Zhangab and Wei Tana (2012) shows sets up of scientific, reasonable performance evaluation system using simply AHP which is especially suitable for the small and medium 3PLs enterprise from the five levels of financial, customers, transportation, storage and technology. In service quality, Wenhua Li et al. (2017) proposed a hybrid approach based on fuzzy AHP and 2-tuple fuzzy linguistic method to evaluate in-flight service quality. Service Quality Model (SERVQUAL) as an instrument is used and a hierarchy of the evaluation index system for in-flight service quality was constructed for the study. The ratings of sub-criteria are assessed in linguistic values which are further transformed into 2-tuples and the 2-tuple linguistic arithmetic mean operator is used to obtain the average ratings of 100 respondents. Tüysüz, F., and Şimşek, B. (2017) presented Hesitant fuzzy sets-based analytic hierarchy process method for analyzing the factors affecting the performance of the branches of a cargo company and also for prioritizing them according to their level of importance.

Satty's Nine-point scale (referred from Satty (1994))

Intensity of Importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Weak importance of one over other	Experience and judgment slightly favor one activity over another
5	Essential/Strong Important	Experience and judgment slightly favor one activity over another
7	Demonstrated importance	An activity is favored very strongly over another; its dominance 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 the two adjacent judgments	When compromise is needed
Reciprocal of the above non-zero	If activity i has one of the above nonzero numbers assigned to it when compared with activity j then j has the reciprocal value when compared with i	A reasonable assumption
Rationals	Ratios arising from scale	If consistency were to be forced by obtaining n numerical values to span the matrix

Figure 1

AN INTEGRATED FUZZY-AHP METHODOLOGY

Fuzzy-AHP (FAHP)

Amalgamation of fuzzy set theory with AHP generate fuzzy analytical hierarchical process (FAHP) and was defined by Huang and Wu (2005) in three steps. "The first involves using triangular fuzzy numbers to transform the ideas of experts into a positive reciprocal matrix. Second, a geometric mean method that weighs the fuzzy values for each option, with the

established hierarchical connection and finally, a membership function for each option that developed the ranking of priorities.”In practice, AHP has two basic applications (Cheng and Li, 2002). First, the traditional use of it is to assign weights to a set of pre-determined elements (e.g criteria, factors) and second, make decision(s) out of several alternatives. When a hierarchy has only three levels, the AHP method is equivalent to the classical Simple Additive Weighting (SAW) method (which is also known as weighted linear combination or scoring methods is a simple and most often used multi attribute decision technique). We feel that the AHP method is worth utilizing when there are more than three levels in a hierarchy. For the determination of the relative importance of evaluation criteria, fuzzy-AHP can be used since it is based on pair-wise comparisons and allows the utilization of linguistic variables. From paired comparisons a relative scale of measurement is derived. Although the pair-wise comparison approach is demanding in terms of solicited input from the experts, it offers maximum insight, particularly in terms of assessing consistency of the experts’ judgment. This technique is ideal for closer examination of a selected set of performance measurement criteria in total quality management context. Saaty (1980, 1994) listed several benefits of AHP. First, it helps to decompose an unstructured problem into rational decision hierarchy (similar to decision tree). Second, it can elicit more information from the experts or decision makers by employing the pair-wise comparison of individual groups of elements. Third, it sets the computations to assign weights to the elements. Fourth, it uses the consistency measures to validate the consistency of the rating from the experts and decision makers. It is, therefore, argued to be composed of both qualitative and quantitative substances. Saaty, T. L. (1990) stated that, “The most effective way to rationalize judgments is to take a pair of elements and compare them on a single property without concern for other properties or other elements”. Pair-wise comparisons in the AHP assume that the decision-maker can compare any two elements $E_i E_j$, at the same level of the hierarchy and provide a numerical value ij a for the ratio of their importance. If the element E_i is preferred to E_j , then; $a_{ij} > 1$. Correspondingly, the reciprocal property; $a_{ji} = 1/a_{ij}$; $a_{ij} > 0$, for $i = 1, 2, \dots, n$ and $j = 1, 2, \dots, n$ always holds. Each set of comparisons for a level with n elements requires $n(n-1)/2$ judgments, which are further used to construct a positive reciprocal matrix of pair wise comparisons

The positive reciprocal comparison matrix of criteria weights is given as:

$$A = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{bmatrix} \quad (1)$$

The geometric mean of each row is calculated as:

$$Z_i = \left[\prod_{j=1}^n a_{ij} \right]^{1/2} \text{ for } i; j = 1, 2, \dots, n \quad (2)$$

The weight W_i is calculated as, $W_i = Z_i / (Z_1 + Z_2 + \dots + Z_n)$, $\forall i = 1, 2, \dots, n$ (3)

The values in the scale of relative importance is crisp numeric values

Equal Importance	Moderate Importance	Strong Importance	Very Strong Importance	Extreme Importance	Intermediate Values	Values for Inverse Comparison
1	3	5	7	9	2,4,6, 8	1/3,1/5,1/7 & 1/9

Scaling for Fuzzy –AHP

Figure 2 Fuzzy Evaluation Scale for TQM CSFs

Categories	Equally Importance	Intermediate Preference	Moderately More Important	Intermediate Preference	Strongly More Important	Intermediate Values	Very Strong More Important	Intermediate Preference	Extremely More Important
Triangular Fuzzy AHP	1,1,1	1,2,3	2,3,4	3,4,5	4,5,6	5,6,7	6,7,8	7,8,9	9,9,9
	1,1,1	1/3,1/2,1	1/4,1/3,1/2	1/5,1/4,1/3	1/6,1/5,1/4	1/7,1/6,1/5	1/8,1/7,1/6	1/9,1/8,1/7	1/9,1/9,1/9

To facilitate the calculation of fuzzy weights, the following arithmetic operations of triangular fuzzy numbers are presented. A triangular fuzzy number (TrFN) can be defined as $A = (\ell, m, u)$ where $0 \leq \ell \leq m \leq u$ as shown in Fig. 1, and its membership function is as follows:

$$\mu_A(x) = \begin{cases} \frac{x - \ell}{m - \ell} & \text{for } \ell \leq x \leq m; \\ \frac{u - x}{u - m} & \text{for } m \leq x \leq u; \\ 0, & \text{for Otherwise;} \end{cases} \quad (4)$$

Figure 1 Membership function of TrFN

Let $u = (\ell_1, m_1, u_1)$ and $v = (\ell_2, m_2, u_2)$ be two TrFNs. Where ℓ, m, u for Lower, Middle and Upper significant membership function. The interval (ℓ, u) expresses the closure of the support of $\tilde{A}$, and the middle significant value m represents the core of $\tilde{A}$. A real number $A \in \mathbb{R}$ can be viewed as a triangular fuzzy number.

Next to defuzzify the TrFN $m = (\ell_1, m_1, u_1)$, the following equation can be used:

$$W_i = \frac{\ell_1 + m_1 + u_1}{3} \text{----- (5)}$$

STEPS OF THE PROPOSED FUZZY-AHP ALGORITHM

The proposed method consists of some simple steps which have been outlined in the following sections. This method may be used for both group as-well-as individual decision-making.

Step I: Determining the Attributes. The attributes i.e. TQM drivers, enablers and capabilities are selected on the recommendation of analyst opinion. The attributes which have some sub-attributes are not included in the decision-making process. In other words, the final level of the hierarchical decision-making diagram (i.e., attributes) is involved in decision making.

Step II: Evaluate the relative importance of the criteria using pair-wise comparisons. The experts are required to provide their judgments on the basis of their knowledge and expertise. The experts' linguistic preferences are converted into triangular fuzzy numbers using Table 2.

Step III: Aggregate experts' individual preferences into group preference by applying the fuzzy triangular averaging operator, which is defined by

$$a_{ij} = \frac{1}{K} [a_{ij}^1 (+) a_{ij}^2 (+) \dots \dots \dots + a_{ij}^j] ,$$

Where K is the number of experts and a_{ij}^j (6)

Is the evaluation of the K^{th} decision maker on the pair-wise importance comparison of j^{th} and k^{th} criteria.

Step IV: Obtain the fuzzy weights W_i . The derivation of $\tilde{z}_j$ values (Eq. (2)) and fuzzy weights $\tilde{W}_j$ (Eq. (3)) can be detailed as follows.

Let:

$$a_j = \left[\prod_{k=1}^n a_{jk} \right]^{1/n} \text{ and } a_j = \sum_{j=1}^n a_j \text{----- (7)}$$

The fuzzy weight $(\tilde{W}_i)$ of every attribute is computed in Eq. (3) which involves 3 sub-processes. Initially, the vector summation of every $\tilde{r}_i$ is found. Next, the inverse of summation vector is done and replaces the TrFN. Finally, the $\tilde{W}_i$ is calculated by multiplying every $\tilde{r}_i$ with its reverse vector.

Step V: Defuzzify and normalize the triangular fuzzy weights.

To defuzzify the TrFN in Eq. (8), the following equation is used:

$$W_i = \frac{d_i + m_i + u_i}{3} \quad (8)$$

And, to normalize the crisp weights Eq. (9) is used: $W_j = \frac{w_j}{\sum_{j=1}^n w_j}$, $j=1,2,\dots,n$ (9)

MODEL VALIDATION: A CASE OF INDIAN FMCGS COMPANY

Fast Moving Consumer Goods (FMCGs) industries captures oligopolistic market, so being sustain in the global market, recurrently measurement of performance become essential task. In order to determine the performance of the implemented total quality management which strongly depends on its critical success factors and capabilities, the linguistic data is collected including all levels of management viz, Low level, Medium level and Top level through questionnaire. The involvement of all three levels is to nullify the biasness of the response provided and meet the requirements of TQM as well and observed that mostly using chomskyan linguistics. The vision behind involvement the employees of three levels to form a quality circle. As it is well known fact that the quality circle helps to find out relationship between different factors in the organization and their effect on each other so that we can find out major and minor factors based upon ranking which management can take action to improve organization effectiveness. Zbaracki (1998) the concept of TQM provides a simple and essential description of quality management that allows middle and upper level managers to oversee product and service quality in direct and uncomplicated manner. The primary objective associated with modeling for performance measurement is to identify the various critical factors, interacting operations in a realistic manner. Achieving this objective is complicated by existing TQM barriers, if any. Given the complexity of operations and the uncertainty associated with several of these factors, FAHP was identified as an important decision-making tool for use in understanding, quantifying, and improving performance. During an actual study of organization and its operation environment, a decision maker will monitor multiple performance measures. These include existing TQM drivers, enablers, and capabilities for all types of factors. TQM drivers represent the bottom line and are considered the most important performance measure. TQM enablers, which is positively correlated with drivers, and both reinforce the capability of TQM. In total 14 attributes were considered for 03 criteria for the present condition (Table 1). On the basis of collected information hierarchy is developed for the evaluation (Figure 1).

Table 1: Performance Measurement Criteria of TQM

Level I	Level II	Level III	Level IV
GOAL	CRITERIA	ALTERNATIVES	
TQM Objectives/Goal	TQM Drivers	Top Level Management	Organizational Performance
		Customer Focus	
		Continuous improvement and innovation	
		Supplier management	
		Employee involvement	
		Quality Information /Information Quality	
		Benchmarking	
	TQM Enablers	Culture and communication	
		Employee Encouragement and Motivation	
		Training and education	
	TQM Capabilities	Zero Defect	
		Waste Reduction	
		Continuous Improvement Process	
		Performance Improvement

Figure 1 Hierarchy Based Performance Measurement Model

TQM Drivers: D_1 -Top Level Management; D_2 -Customer Focus/Customer Centricity; D_3 - Continuous improvement and innovation; D_4 - Supplier management; D_5 -Employee involvement; D_6 -Quality Information /Information Quality; D_7 -Benchmarking

TQM Enablers: E_1 - Culture and communication; E_2 - Employee encouragement and motivation; E_3 - Training and education

TQM Capability: C_1 -Zero Defect; C_2 -Waste Reduction; C_3 - Continuous Improvement Process; C_4 -Performance Improvement

To implement the method, it was necessary the support of an expert in decision-making methods and of those engaged for TQM implementation in the FMCGs industry studied here. The support of the decision-making expert was necessary since he was responsible for telling the TQM staff how the judgments should be performed, how the program should be used and what maximum value should the inconsistency take. Experienced people were chosen from and formed three groups of evaluators. Table 2 presents the comparisons among TQM practices, provided by Group experts. The comparison matrix presented in Table 2 is consistent. Remarkably, all the comparison matrices provided by the Group experts were consistent. These are indications that the experts were aware about their judgement.

Table 2: Pair-Wise Comparison of the Three Main Criteria with Respect to the TQM Practices

TQM Goal based on	DRIVERS	ENABLERS	CAPABILITIES	PRIORITY
DRIVERS	1	3	5	65.2 %
ENABLERS	1/3	1	2	22.3 %
CAPABILITIES	1/5	1/2	1	12.5 %

The Aggregation of Individual Priorities (Saaty and Peniwati, 2007) was applied to aggregate their comparisons. The experts were considered as equally important. That is, their priorities had the same weight when aggregated.

Explanation of the attributes of TQM used is as:

Oakland (1993) suggested ten basic steps in the implementation of TQM projects from that the extracted points which emphasizes critical success factors are as about: Develop the mission onto its critical success factors (CSFs) to coerce and move it forward, Breakdown the critical success factors into the key or critical process and gain process ownership as-well-as prepare project quality plans for all levels of work and Breakdown the critical success factors into sub-processes, activities and tasks and form improvement teams around these.

Top level management (D₁) Top level management is the one, which is responsible for a firm's strategy, can also be judged how performance is scaled for improvement. The majority of respondents reported "the lack of complete top management commitment from the start, and through the process" to be the obvious barrier to TQM success. The achievement of organizational goals is based on top management teams' ability to anticipate and respond to external change (Burgelman, 1991; Child, 1972). W. C. Auden et al. (2006) emphasized as summary of the work that the top management team seems to have a strong influence on the firm's performance.

Customer focus/Customer Centricity(D₂) Customer Focus involves researching what customers or end users want from products or services. Prajogo and Cooper (2010) argue that quality customer service is one of the most important aspects of TQM because in any customer-oriented business the customers are the organisation's main stakeholders. Nair (2006) highlighted the importance of customer focus by demonstrating evidence of a strong relationship between customer focus and firm performance. Moreover, customer focus receives attention as a CSF, because every effort of TQM is a customer orientated.

Continuous improvement and innovation (D₃) TQM practices enhance competitive performance by improving the quality of products and processes. The continuous improvement leads to dynamic outcomes of innovation, namely product innovation – changes in the specific products/services offered to the customers and process innovation – and changes in the mode by which the products are created or delivered. Innovation refers to an outcome perceived as new, regardless of whether it is an idea, object or process, as well as to the process of creating this newness (Slappendel, 1996).

Supplier's management (D₄) supplier's management acts as an interface between TQM and Supply Chain Management (SCM). Managing the flow of goods between the manufacturer and customers is a fundamental part of organizations. To accomplish this the well-trained employees, ensure consistent, reliable and secure supply. Material traceability is always also maintained through robust quality management systems. Vanichchinchai, A. and Igel, B. (2011) investigated the relationships among total quality management practices (TQMP), supply chain management practices (SCMP) and firm's supply performance (FSP) in the automotive industry in Thailand and found that the set of SCMP, TQMP and FSP measures are reliable and valid. Gunasekaran and McGaughey (2003) earlier also suggested that TQM could play a key role in improving SCM.

Employee Involvement: (D₅) The negative implications of TQM and performance management inconsistency is also compounded by the fact that employee's engagement in designing and implementing the performance management system, in the majority of organizations, is quite low. The survey on employee engagement reported in Gallup Management Journal (2002) according to the report (see, for further details, gmj.gallup.com), "more than half of the employees may not be engaged with their work". Involvement of employee automatically empowers the people to make decisions, make choices, take risks, and make new contributions. This congruity, in turn, will improve employee motivation and attitudes towards effective implementation of TQM initiatives.

Quality Information/Information Quality (D_6) To have an effective TQM implementation, organization must ensure that data are valid and reliable. They measure what they are supposed to consistently, and employees should have access to the data that are needed to carry out the tasks, Seetharaman, A. et al. (2006). Lakhal et al. (2006) establish through study and confirm the relevance of data-based factual decision-making by pointing out that information and analysis have a significant direct effect on various performance measures. Information and analysis and plant performance are correlated positively, years back shown by Choi and Eboch (1998) in their study.

Benchmarking (D_7) Benchmarking aims to measure organization's operations or processes against the best-in-class performers from inside or outside its industry. The usefulness of benchmarking for improving the performance of the organization and to achieve competitive advantage help in continuous service improvements and establishment of customer satisfaction. Benchmarking can significantly affect the improvement of key business processes and consequently, increase the quality level, Hietschold, N. et al. (2014). Without benchmarking, organisations do not know their relative performance and they probably fail to design processes more effectively (Rao, S. et al. 1999).

Culture and communication (E_1): Competent organizational culture can be defined as, a set of congruent behaviors, attitudes, and policies that come together in a system, agency, or among professionals that enable them to work effectively in cross cultural situations. (Saldana, 2001). Culture is important to improve the communication among top-to-bottom, bottom-to-top and across the departments, in which the information is shared by each staff. Antony, J. et al. (2002). As a concept, 'Quality' implies that an organization understands what customers require of a product or service, and is able not only to meet this requirement but can also exceed the expectations of the customer. This demands a particular culture that can in fact, be seen to be embedded in TQM philosophy, which embraces the idea of encouraging an organization to strive for continuous improvement in its values and methods of operation in order to achieve customer satisfaction.

Employee encouragement and motivation (E_2) White and Nebeker (1996, p. 210) in their review of "reward and recognition and their functions in TQM organizations" point out that: A team-based perspective that focus on process improvement and personal development could improve effectiveness of performance appraisal as well as TQM objectives. Soltani, E. et al. (2005) survey indicated that their performance management systems in relation to having a positive impact on employee motivation towards successful implementation of quality programs were "very" and "moderately" effective.

Training and education (E_3) Mital et al. (1999) along with group of fifteen co-authors recommend that there is a dire need to train workers in manufacturing organizations and thereby improve the overall effectiveness and efficiency of such organizations. Further also mentioned that in order to compete successfully in the global market, manufacturing organizations must aim at training workers in skills necessary to produce quality goods. Strong correlation between quality performance and employee training is established in a study by Solis et al. (2000).

Zero-defect (C_1) Zero Defects focuses on conditioning the employee to ensure a personal interest serves as motivation in everything they do. This is done by motivating the employee towards work importantly for the success of the organization. Specific goals, based on the customer's requirements (Linderman, K. et al., 2003) that are grounded on a philosophy of continuous improvements, all the points that combines TQM, Zero Defect Mindset (ZDM) and Six Sigma together. Total quality management models tend to incorporate the zero-defect vision by maximizing the overlap of customer demands and delivered product features, while costs have to be minimized, M. Colledani et al. (2014).

Waste reduction (C_2) The increase in lead-time also causes quality related phenomena which reduces the observability of the critical product quality feature in the system, further reduces the ability to detect a potentially generated defect within a short time. Colledani et al. (2014) stated that this directly translates into the propagation of more defects between the processing stages in the system and a waste of production capacity in processing parts that are already defective. A loss of capacity leads to a loss of total throughput.

Continuous improvement process (C_3) Walsh, A. et al. (2002), outlook that many organizations show great enthusiasm for TQM during the initial year of TQM initiatives but then fall victim to a lackluster attitude towards its continuation. Lastly authors concluded with emphasizing that it is most important to remember that successful TQM strategies are based around the concept of continuous improvement. The continuous improvement of the process leads to customer satisfaction, which results in an external quality improvement. The continuous improvement also leads to fewer defects, which results in an internal quality improvement (Dahlgard et al., 1994).

Performance improvement (C_4) TQM is not limited to shop floor; it may be applied throughout the enterprise. This encompasses whole functions of the organization. TQM provides a single, unifying approach for the entire enterprise using performance improvement as the capability. This capability of TQM is important for organizations that offer high-variety and custom products today, but it will become increasingly important as we look to the future with mass customization.

To achieve the goal of the TQM through existing drivers, enablers and capabilities is shown in figure 1 with respective factors as sub-criteria. This work may be extended by considering the sub sub-criteria of each factor, which is not considered in this research.

Performance Measurement Based on Fuzzy AHP Methodology

After determining the evaluation criteria and the alternatives, the steps of the integrated fuzzy AHP algorithm are implemented. To obtain the importance of each factor first the experts utilised saaty's nine point scale, and result is obtained. Table 3 gives the results of the pair-wise comparisons of the evaluation criteria made by experts. Tables 2 and 3, the aggregated fuzzy evaluation matrix for the criteria weights is obtained as in Table 4.

Table 3: Pair-Wise Comparison of Attributes of TQM

TQM		Drivers							Enablers			Capabilities			
		D_1	D_2	D_3	D_4	D_5	D_6	D_7	E_1	E_2	E_3	C_1	C_2	C_3	C_4
Drivers	D_1	1	9	5	7	3	7	5	4	4	6	4	5	5	7
	D_2	1/9	1	2	5	2	4	2	2	2	2	4	2	2	3
	D_3	1/5	1/2	1	2	3	7	4	7	5	3	8	8	9	5
	D_4	1/7	1/5	1/2	1	2	8	2	3	3	2	6	5	4	5
	D_5	1/3	1/2	1/3	1/2	1	5	4	7	9	5	7	7	6	6
	D_6	1/7	1/4	1/7	1/8	1/5	1	3	4	3	3	5	4	5	7
	D_7	1/5	1/2	1/4	1/2	1/4	1/3	1	3	3	2	4	4	4	6
Enablers	E_1	1/4	1/2	1/7	1/3	1/7	1/4	1/3	1	5	3	5	5	6	4
	E_2	1/4	1/2	1/5	1/3	1/9	1/3	1/3	1/5	1	3	5	5	7	5
	E_3	1/6	1/2	1/3	1/2	1/5	1/3	1/2	1/3	1/3	1	3	3	5	5
Capabilities	C_1	1/4	1/4	1/8	1/6	1/7	1/5	1/4	1/5	1/5	1/3	1	9	7	9
	C_2	1/5	1/2	1/8	1/5	1/7	1/4	1/4	1/5	1/5	1/3	1/9	1	5	7
	C_3	1/7	1/3	1/5	1/5	1/6	1/7	1/6	1/4	1/5	1/5	1/9	1/7	1	9
	C_4	1/7	1/3	1/5	1/5	1/6	1/7	1/6	1/4	1/5	1/5	1/9	1/7	1/9	1

For pairwise comparisons of criteria and alternatives, Saaty (1994) defined a scale of integers from 1 to 9 that express how many times more important or dominant one attribute is over another one. To each number from the scale assigned a linguistic term describing the intensity of importance or dominance of one attribute over another. Generally, integers 1, 3, 5, 7 and 9 are used for making pair wise comparisons of attributes. In case where more detailed comparisons are desirable then intermediate values 2, 4, 6, and 8 is selected. A square pair wise comparison matrix $A = [a_{ij}]_{i,j=1}^p$ is constructed ($p = 14$, in our case), Table 3. An element a_{ij} expresses how many times more important x_i is over x_j with respect to a particular object from the upper level of the hierarchy. It is obvious that $a_{ii} = 1$, $i = 1, \dots, p$, as we compare x_i with itself. Further, when object x_i is a_{ij} -times more important than object x_j , then obviously object x_j takes only the $1/a_{ij}$ -th of the importance of object x_i . Therefore, the pairwise comparison matrix $A = [a_{ij}]_{i,j=1}^p$ is reciprocal, i.e. $a_{ji} = 1/a_{ij}$ for all $i, j \in \{1, \dots, p\}$.

As this work is carried in an Indian FMCGs industry, so in real-world decision- making problems, the information provided by decision makers is often vague because the information is given by means of linguistically. Thus, fuzzy AHP has been developed in order to deal with vagueness and imprecision. Many different approaches to the fuzzification of Saaty's scale have been proposed in the literature. The authors expressed the meaning of the linguistic terms by triangular fuzzy numbers.

Using the elements from a considered fuzzified scale, a fuzzy pairwise comparison matrix $A = [\tilde{a}_{ij}]_{i,j=1}^p$ is constructed (Table 4), i.e. $\tilde{a}_{ii} = \tilde{1}$, $i = 1, \dots, p$, and $\tilde{a}_{ji} = 1/\tilde{a}_{ij}$ for all $i, j \in \{1, \dots, p\}$.

Table 4: With Fuzzy Numbers

TQM		Drivers							Enablers			Capabilities			
		D ₁	D ₂	D ₃	D ₄	D ₅	D ₆	D ₇	E ₁	E ₂	E ₃	C ₁	C ₂	C ₃	C ₄
Drivers	D ₁	1,1,1	9,9,9	4,5,6	6,7,8	2,3,4	6,7,8	4,5,6	3,4,5	3,4,5	5,6,7	3,4,5	4,5,6	4,5,6	6,7,8
	D ₂	1/9,1/9,1/9	1,1,1	1,2,3	4,5,6	1,2,3	3,4,5	1,2,3	1,2,3	1,2,3	1,2,3	3,4,5	1,2,3	1,2,3	2,3,4
	D ₃	1/6,1/5,1/4	1/3,1/2,1	1,1,1	1,2,3	2,3,4	6,7,8	3,4,5	6,7,8	4,5,6	2,3,4	7,8,9	7,8,9	9,9,9	4,5,6
	D ₄	1/8,1/7,1/6	1/6,1/5,1/4	1/3,1/2,1	1,1,1	1,2,3	7,8,9	1,2,3	2,3,4	2,3,4	1,2,3	5,6,7	4,5,6	3,4,5	4,5,6
	D ₅	1/4,1/3,1/2	1/3,1/2,1	1/4,1/3,1/2	1/3,1/2,1	1,1,1	4,5,6	3,4,5	6,7,8	9,9,9	4,5,6	6,7,8	6,7,8	5,6,7	5,6,7
	D ₆	1/8,1/7,1/6	1/5,1/4,3/4	1/8,1/7,1/6	1/9,1/8,1/7	1/6,1/5,1/4	1,1,1	2,3,4	3,4,5	2,3,4	2,3,4	4,5,6	3,4,5	4,5,6	6,7,8
	D ₇	1/6,1/5,1/4	1/3,1/2,1	1/5,1/4,3/4	1/3,1/2,1	1/5,1/4,3/4	1/4,1/3,1/2	1,1,1	2,3,4	2,3,4	1,2,3	3,4,5	3,4,5	3,4,5	5,6,7
Enablers	E ₁	1/5,1/4,3/4	1/3,1/2,1	1/8,1/7,1/6	1/4,1/3,1/2	1/8,1/7,1/6	1/5,1/4,3/4	1/4,1/3,1/2	1,1,1	4,5,6	2,3,4	4,5,6	4,5,6	5,6,7	3,4,5
	E ₂	1/5,1/4,3/4	1/3,1/2,1	1/6,1/5,1/4	1/4,1/3,1/2	1/9,1/8,1/7	1/4,1/3,1/2	1/4,1/3,1/2	1/6,1/5,1/4	1,1,1	2,3,4	4,5,6	4,5,6	6,7,8	4,5,6
	E ₃	1/7,1/6,1/5	1/3,1/2,1	1/4,1/3,1/2	1/3,1/2,1	1/6,1/5,1/4	1/4,1/3,1/2	1/3,1/2,1	1/4,1/3,1/2	1/4,1/3,1/2	1,1,1	2,3,4	2,3,4	4,5,6	4,5,6

Capabilities	C ₁	1/5,1/ 4,3/4	1/5,1/ /4,3/ 4	1/9,1/ 8,1/7	1/7,1/ 6,1/5	1/8,1/ /7,1/ 6	1/6,1/ /5,1/ 4	1/5,1/ /4,3/ 4	1/6,1/ /5,1/ 4	1/6,1/ /5,1/ 4	1/4,1/ /3,1/ 2	1,1,1	9,9,9	6,7,8	9,9,9
	C ₂	1/6,1/ 5,1/4	1/3,1/ /2,1	1/9,1/ 8,1/7	1/6,1/ 5,1/4	1/8,1/ /7,1/ 6	1/5,1/ /4,3/ 4	1/5,1/ /4,3/ 4	1/6,1/ /5,1/ 4	1/6,1/ /5,1/ 4	1/4,1/ /3,1/ 2	1/9,1/ /9,1/ 9	1,1,1	4,5,6	6,7,8
	C ₃	1/8,1/ 7,1/6	1/4,1/ /3,1/ 2	1/6,1/ 5,1/4	1/6,1/ 5,1/4	1/7,1/ /6,1/ 5	1/8,1/ /7,1/ 6	1/7,1/ /6,1/ 5	1/5,1/ /4,3/ 4	1/6,1/ /5,1/ 4	1/6,1/ /5,1/ 4	1/9,1/ /9,1/ 9	1/8,1/ /7,1/ 6	1,1,1	9,9,9
	C ₄	1/8,1/ 7,1/6	1/4,1/ /3,1/ 2	1/6,1/ 5,1/4	1/6,1/ 5,1/4	1/7,1/ /6,1/ 5	1/8,1/ /7,1/ 6	1/7,1/ /6,1/ 5	1/5,1/ /4,3/ 4	1/6,1/ /5,1/ 4	1/6,1/ /5,1/ 4	1/9,1/ /9,1/ 9	1/8,1/ /7,1/ 6	1/9,1/ /9,1/ 9	1,1,1

For $i=j$, there is obviously no fuzziness in the comparison, and thus, $\tilde{a}_{ji}$ has to be set as (1, 1, 1) for any $i \in \{1, \dots, p\}$. On the other hand, when two different attributes x_i and $x_j, i \neq j$, are assessed to be “equally important”, then this comparison may contain some fuzziness.

K Teknomo, (2006) suggested that in practice, don't need measurement of inconsistency Random Index (RI) for more than $n=7$ because the number of pair comparisons $n*(n-1)/2$ become so large. Too many questions on the same things make people confuse to answer them correctly. Utilize the hierarchy by grouping some criteria into a higher level hierarchy of the criteria. As in this present study number of attributes considered by authors is 14, which is more than 7, so random indexing is exempted.

When the pairwise comparison matrix of objects is constructed, weights of the factors can be computed from the matrix. Based on Buckley's (1985) method, the geometric mean (Table 5) of fuzzy comparison value of every attribute is computed and formulated in equation below. This method is used because it is easy to extend to the fuzzy case and guarantees a unique solution to the reciprocal comparison matrix. The weight assessing method by geometric mean is chosen for its simplicity and ease in its application to the fuzzy case, Kaya, T., and Kahraman, C. (2011).

Formula used to obtain Fuzzy Geometric Mean Value of each attribute is calculated as

$$\begin{aligned}\tilde{A}_1 \otimes \tilde{A}_2 &= (\ell_1, m_1, u_1) \otimes (\ell_2, m_2, u_2) \\ &= (\ell_1 + \ell_2, m_1 + m_2, u_1 + u_2)\end{aligned}$$

Table 5: Fuzzy Geometric Mean

Fuzzy Geometric Mean values				
	l	m	u	
D ₁	3.807	4.652	5.460	3.807, 4.652, 5.460
D ₂	1.160	1.879	2.529	1.160, 1.879, 2.529
D ₃	2.363	3.013	3.730	2.363, 3.013, 3.730
D ₄	1.316	1.836	2.395	1.316, 1.836, 2.395
D ₅	1.998	2.467	3.166	1.998, 2.467, 3.166
D ₆	0.937	1.176	1.432	0.937, 1.176, 1.432
D ₇	0.848	1.151	1.576	0.848, 1.151, 1.576
E ₁	0.768	0.968	1.252	0.768, 0.968, 1.252
E ₂	0.651	0.812	1.051	0.651, 0.812, 1.051
E ₃	0.548	0.727	1.043	0.548, 0.727, 1.043
C ₁	0.436	0.505	0.606	0.436, 0.505, 0.606
C ₂	0.315	0.377	0.472	0.315, 0.377, 0.472
C ₃	0.235	0.270	0.320	0.235, 0.270, 0.320
C ₄	0.171	0.197	0.234	0.171, 0.197, 0.234

Then Fuzzy weight is calculated of each attribute using formula

$$\tilde{W}_i = \tilde{r}_1 \otimes (\tilde{r}_1 \oplus \tilde{r}_2 \dots \oplus \tilde{r}_n)^{-1} \text{ Also, } \tilde{A}_1 \oplus \tilde{A}_2 = (\ell_1, m_1, u_1) \oplus (\ell_2, m_2, u_2) \\ = (\ell_1 + \ell_2, m_1 + m_2, u_1 + u_2)$$

Table 6: Fuzzy Weights

	Fuzzy Weights			
	l	m	u	
D ₁	0.151	0.232	0.351	0.151,0.232,0.351
D ₂	0.046	0.094	0.163	0.046,0.094,0.163
D ₃	0.094	0.150	0.240	0.094,0.150,0.240
D ₄	0.052	0.092	0.154	0.052,0.092,0.154
D ₅	0.079	0.123	0.204	0.079,0.123,0.204
D ₆	0.037	0.059	0.092	0.037,0.059,0.092
D ₇	0.034	0.057	0.101	0.034,0.057,0.101
E ₁	0.030	0.048	0.081	0.030,0.048,0.081
E ₂	0.026	0.041	0.068	0.026,0.041,0.068
E ₃	0.022	0.036	0.067	0.022,0.036,0.067
C ₁	0.017	0.025	0.039	0.017,0.025,0.039
C ₂	0.012	0.019	0.030	0.012,0.019,0.030
C ₃	0.009	0.013	0.021	0.009,0.013,0.021
C ₄	0.007	0.010	0.015	0.007,0.010,0.015

Fuzzy weights are defuzzified using Centre of area (COA) method to get the crisp values for all the factors considered for the study and then normalised. The value obtained $w_{\text{total}} > 1$, so it must be normalised. On the basis of the normalised values the ranking of TQM attributes demonstrated that impact on its performance. It is observed that Top level management (D₁) is given the highest ranking for these factors with normalised weight (0.180). The rankings of collected factors for each category aggregately are computed in a similar manner.

Table 7: Priority Weights of Alternatives

			De-fuzzified weights using centroid method	normalised weights	Ranking
			$W_i = \frac{\ell_i + m_i + u_i}{3}$	$\frac{W_i}{\sum W_i}$	
	D ₁	0.151,0.232,0.351	0.244646176	0.180	1
	D ₂	0.046,0.094,0.163	0.100766316	0.079	4
	D ₃	0.094,0.150,0.240	0.161247026	0.120	2
	D ₄	0.052,0.092,0.154	0.099234373	0.076	5
	D ₅	0.079,0.123,0.204	0.135261797	0.101	3
	D ₆	0.037,0.059,0.092	0.062610712	0.047	7
	D ₇	0.034,0.057,0.101	0.064129672	0.049	6
	E ₁	0.030,0.048,0.081	0.053090707	0.040	8
	E ₂	0.026,0.041,0.068	0.044620883	0.033	9
	E ₃	0.022,0.036,0.067	0.041682472	0.032	10
	C ₁	0.017,0.025,0.039	0.027134575	0.020	11
	C ₂	0.012,0.019,0.030	0.020549803	0.015	12
	C ₃	0.009,0.013,0.021	0.014453461	0.011	13
	C ₄	0.007,0.010,0.015	0.010559698	0.008	14
Total of De-fuzzified weights, w_{total}			1.079987671		

For interpretation of the result the rank is considered and termed them that they are acting as barriers to the TQM and must be take care of. As Performance improvement (C_4) is measured 14th rank, is the most potential barrier identified.

In this way, the proposed performance model/framework is for the implemented TQM process, is evolvable, perfective or preventive changes may be introduced when needed, is specific for target FMCGs, more CSFs have been involved at different levels and has been evaluated mathematically, and then validated appropriately.

MANAGERIAL IMPLICATION AND CONCLUSION

In this practical work integrated FAH approach is proposed for solving a complex decision-making task related to TQM. To validate the potentiality of our approach we have analysed the implemented TQM of FMCGs industry. In the published research work, FAHP, based on the extent analysis method was used to derive the relative importance between the critical success factors and organisational performance. We have used the same pairwise comparison matrix as given in this original work and have utilized Buckley's FAHP approach (geometric mean approach) to calculate the relative importance among the risk factors. In the next task, to rank the attributes, we have proposed the normalization formulae to calculate the rank in practical manner. We believe that our approach is computationally faster, more accurate and requires less computational steps than the other performance assessment method. Although we have not compared our ranking result with any other work of the FAHP. Apart from that, when the number of critical success factors and alternatives are increased, our approach is sufficient to handle that situation and still provides credible ranking results. Next, we have proposed a quite simpler to interpret and is derived from simpler human reasoning. This integrated approach is believed to be a feasible choice among the performance measurement in industries to support the performance assessment task of other incorporated sub-systems like SCM, Six-Sigma, JIT, TPM etc. Apart from that, other weight calculation approaches may be use to improve the decision-making process.

Funding: This research did not receive any specific grant from agencies in the public, commercial, or not-for-profit sectors.

Declarations of Interest: None

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