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Quality Function Deployment Method for Selection of Effective Management Tools on Setting EFQM Model

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Abstract. Using the effective management tools that are relevant to the organization's needs for excellence has become so important for the companies to improve their performances and then increase customer satisfaction and gain market shares. Quality function deployment is an efficient and powerful tool in design, development, and planning of products. The main function of quality function deployment is conversion of VOC (voice of customer) to technical characteristics (here organization supposed as customer). This study propose a 9-step HOE(House Of Excellence) model, which is basically a QFD model, and present the use of symmetrical triangular fuzzy numbers(STFNs) to reflect the vagueness in 30 experts' linguistic assessments. The model of this research

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has been tested by means of a real case (Joundy Shapoor Company), finding the relationship between 15 categories of management tools with five EFQM enabler criteria based on the quality function deployment approach to determine for Joundy Shapoor Company the effective management tools to reach excellence. And also the test of the hypothesis of this research has been done by using spearman correlation coefficient.

Keywords: Management tools, european foundation for quality management(EFQM), quality function deployment(QFD), fuzzy analytic hierarchy process(FAHP), symmetrical triangular fuzzy numbers(STFNs).

1. Introduction

QFD was invented in Japan by Yoji Akao in 1966, but was first implemented in the Mitsubishi's Kobe shipyard in 1972, possibly out of the teaching of Deming. Then later it was adopted and developed by other Japanese companies, notably Toyota and its suppliers. QFD (quality function deployment) is defined as a method for developing a design.

So, identifying and using best management tools according to organization's needs in setting EFQM model and achieving results in organizations are so important. The purpose of the current research is to show how organizations can identify, prioritize and select management tools that are effective on setting EFQM model in organizations with a quality function deployment (QFD) model with both crisp and fuzzy approaches for the linkages between the EFQM criteria and management tools.

Quality aiming at satisfying the consumer and then translating the consumer's demand into design targets and major quality assurance points to be used throughout the production phase. QFD is a way to assure the design quality while the product is still in the design stage (American Supplier Institute, 1994). So, the QFD House of Quality displays the relationship between dependent (WHATS) and independent (HOWS) variables (American Supplier Institute, 1994). In this research, WHATs related to five enabler criteria of EFQM and HOWs related to 15 effective management tools. The EFQM model constitutes a non-prescriptive framework that assumes there are different approaches to achieving sustainable excellence (Ghobadin & Woo 1996) that drives

in the existence of multiple interpretations around its implementation. However, it is made up of certain notions and ideas about the general relationships between its elements that have still not been demonstrated empirically (Bou-Llusar et al., 2005). In this sense the logic behind the model is that by improving how the organization operates-"the management tools"-there will be an inevitable improvement in the "results". It means that management tools are the main part of EFQM excellence model and the fact is, achieving excellence is depend on using the best management tools that are adopt with the organization needs for excellence and have a high level of performance in using of those management tools. Previous studies have also emphasized the need of using management tools in developing the excellence in organization (Leonarad & Adam, 2002). So, identifying and using best management tools according to organization's needs in setting EFQM model and achieving results in organizations are so important.

2. Research Hypothesizes

The main hypothesizes of this study can be break down into the 75 hypothesizes that show the meaningful statistical relation between 15 management tools and 5 enabler criteria of EFQM in Joundy Shapoor Company. So the main Hypothesizes is "There is meaningful statistical relation between 15 management tools and 5 enabler criteria of EFQM in Joundy Shapoor Company".

In according to the fuzzy QFD method, the following sub-hypothesizes were set;

• The ranking of effective criteria on setting EFQM model in an organization (the research case) are the same in crisp and fuzzy approaches.

• The ranking of effective management tools on setting EFQM excellence model in an organization (the research case) are the same in crisp and fuzzy approaches.

3. Findings

The basic method of this research is to understand what organization needs are for excellence (such as EFQM enabler criteria like leadership, strategy, etc) and then to identify the important ones through criteria analysis and to associate the organization's needs for excellence with appropriate technical attitudes or solutions (such as management tools like strategic management, production management and etc) and then find the important ones through technical analysis. The QFD of this research has named house of excellence (HOE) because this model basically looking for the excellence improvement in organization by prioritizes the effective management tools on setting EFQM excellence model in organization. So we try to manage an effective relationship between management tools and EFQM criteria and then find out which relationship is stronger than others to propose to Joundy Shapoor Company for improving of excellence performance (Fig.1). So at first the company must determine the experts to reveal their various perceptions about the questions. Here, for illustration purpose, thirty experts of the company from all parts of the company are selected and all of them have the same effect on research analysis. We can describe this research base on 9-step procedures based on the ideas from Chan and Wu (2005) and Yousefie et al (2011).

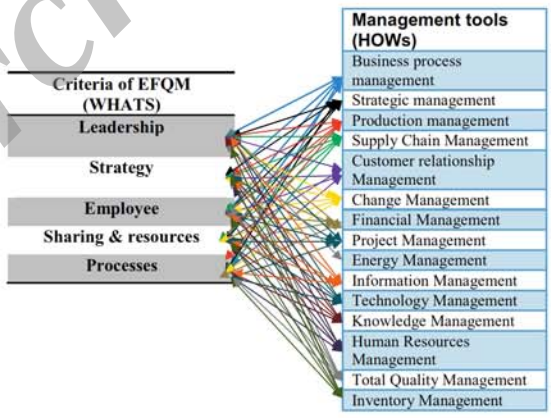

Fig.1. Conceptual model of research

Now we explain this research base on this 9-step procedure:

Step 1: Identify organization needs for excellence (WHATs):
The organization should know what organization need for excellence is important for it; otherwise you can't know how to satisfy your company and thus how to keep your business successful and achieve excellence. By complete research studies about effective criteria on setting EFQM model, 5 enabler criteria of EFQM model as organization's needs for excellence found that we call them WHATs so they are:

1- Leadership
2- Strategy
3- Employee
4- Sharing & resources
5- Processes

Step 2: Determine relative importance rating of organization needs for excellence (WHATs):
Organization needs for excellence (WHATs) usually are of different degrees of importance for company. By putting n=5 that it shows 5 enabler criteria of EFQM in this formula (n (n-1)/2), we should have 10 pair wise comparison. So, by use of 10 pair wises comparison between each two criteria, the 30 experts are asked to reveal their perceptions on the relative importance of the five WHATs. So, each expert should answer ten questions and then by use of group analytic hierarchy process (GAHP) we have 30 matrixes from experts' decisions. So the final comparison matrix can obtain by a geometric mean method. So, this research normalize the numbers and get balance mean to show the relative importance rating of each enabler of EFQM in Joundy Shapoor Company. (Table 1)

Table 1: Final pair wises comparison matrix Normalize

Final Matrix Normalize	Leadership	Strategy	Employee	Sharing & resources	Processes	Balance Mean
Leadership	0/310164	0/148906132	0/430231	0/376932	0/308153	0/314877267
Strategy	0/221085	0/106149225	0/053491	0/083934	0/104703	0/113872475
Employee	0/06408	0/225057586	0/088929	0/195744	0/308153	0/17639281
Sharing & resources	0/211966	0/3257932	0/194559	0/257626	0/087508	0/215490404
Processes	0/192705	0/194093857	0/23279	0/085764	0/191483	0/179367044

Now, in Table 2, you can see the relative importance rating of each enabler of EFQM in Joundy Shapoor Company

Table 2: Relative Importance Rating of each Enabler

Enabler of EFQM	Crisp relative importance	Percentages of relative importance
Leadership	0/314877267	31/4877267
Strategy	0/113872475	11/3872475
Employee	0/17639281	17/639281
Sharing & resources	0/215490404	21/5490404
Processes	0/179367044	17/9367044

The AHP methodology of Satty (1980) provides a consistency ration to measure any inconsistency whit in the judgments in each comparison matrix. The ration can be use to indicate whether or not the largest can be arranged in an appropriate order of ranking and how consistent are the pair wise comparison matrixes. If the calculated consistency rate of a final comparison matrix is less than 0.1 then the consistency of the pair wise judgment can be thought as being acceptable. Otherwise the judgments are inconsistent and they should repeat it. In this research, after calculating the consistency rate of the entire comparison matrix, it was found they are less than 0.1. Therefore, the consistency of the judgment in all the comparison matrices is acceptable.

Group analytic hierarchy fuzzy process: The appropriate ways of obtaining experts' perceptions are by analytic hierarchy process (AHP). AHP is one of the most useful multi criteria decision making methods for rating analysis. According to applying fuzzy numbers in QFD model, we use group analytic hierarchy fuzzy method

So, we use triangular fuzzy numbers (l, m, and u) and applying them to 30 pair wises comparison matrices from experts' decisions. And then, we can obtain fuzzy comparisons matrix by triangular fuzzy numbers (l, m, and u) as you can see in table3.

Table 3: Final Fuzzy comparisons matrix of criterion

		Leadership			Strategy			Employee			Sharing & resources			Processes	
Leadership	1	1	1	1.2968	1.4028	1.4877	4.1195	4.8379	6.03921	1.3642	1.4631	1.5422	1.4142	1.6093	1.9293
Strategy	0.6721	0.7128	0.7711	1	1	1	0.6163	0.6015	0.6967	0.3311	0.3258	0.3996	0.5569	0.5468	1.6817
Employee	0.1969	0.2066	0.2427	2.0296	2.1202	2.4136	1	1	1	0.7711	0.7598	0.84089	1.4142	1.6093	1.9293
Sharing & resources	0.6484	0.6834	0.7329	2.502	3.0692	4.2703	1.9293	2.1878	2.8703	1	1	1	0.4926	0.457	0.5183
Processes	0.6163	0.6213	0.7071	1.6817	1.8285	2.1351	2.2133	2.6177	3.2447	0.3081	0.3329	0.4143	1	1	1

Now, in Table 4, you can see the fuzzy relative importance rating of each criterion by a FGAHP method.

Table 4: Fuzzy relative importance rating of each criterion

	L	**M**	**U**	**DE fuzzing= (l+2m+u)/ 4**	**Norma lize**	**%**
Leadership	1/838	2/062	2/09	2/013	0/3076	31%
Strategy	0/635	0/637	0/90	0/704	0/1076	11%
Employee	1/082	1/139	1/14	1/126	0/1721	17%
Sharing & resources	1/314	1/479	1/30	1/394	0/2130	21%
Processes	1/168	1/280	1/50	1/306	0/1995	20%

Step 3: Identify competitors and conduct organization competitive analysis:

Competitors who produce the similar products should be identified by the company under study. Knowing the company's strengths and constraints in all aspects of excellence and in comparison with its main competitors is essential for a company if it wishes to improve its competitiveness in the relevant market. (Yousefie et al 2011) So this step is for Joundy Shapoor Company to identify competitors and conduct excellence competitive analysis

In this market, Joundy Shapoor has four main competitors:

1- Pidek Company

2- Hampa Company
3- Jahan Pars Company
4- Foreigner Companies

In order to understand the Joundy Shapoor market and its relative position in the market, it asks all the 30 experts to rate the relative performance of its own company and its four competitors' similar products in terms of the five WHATs, an excellence comparison matrix can be obtain by averaging their assessments. Joundy Shapoor experts with management help set improving goals on each WHAT to better satisfy the organizations' needs for excellence. Based on Chun model, goal level should determine in a way that there isn't any big gap between current performance and goal performance level (Table 5).

Table 5: current performance and goal performance

WHATs	Current performance of Joundy Shapoor	Goal performance	Improvement ratio U_m	GAP
Leadership	6/1117	7	1/145344	14/53
Strategy	5/493	7	1/274349	27/43
Employee	5/628	7	1/243781	24/37
Sharing & resources	6/1706	7	1/134411	13/44
Processes	5/8808	7	1/190314	19/03

According to Joundy Shapoor current and goal performance levels on the five WHATs, its improvement ratio with respect to the organizations' needs can be computed according to the formula 1:

$$ImprovementRatioUm = Goal/Xm \qquad (1)$$

Now by applying the entropy method company's competitive priority rating can be obtained from formula 2:

$$e_i = E(W_i)/\sum E(W_i)\ criterion\ weights \qquad (2)$$

Step 4: Determine final importance rating of WHATs:

Organization needs (W_m) final importance rating for the company is determined jointly by its relative importance (g_m), competitive priority (e_m) and improvement ratio (W_m) as:

$$F_m = U_m \times g_m \times e_m \qquad m = 1, 2, ..., m$$

Here, final importance ratings are also given as $STFN_s$, so the final importance rating of W_1 in STFN form is computed by;

$$F_1^f = U_1 \times g_1^f \times e_1$$

These final importance ratings of the $WHAT_s$, expressed as both crisp numbers and $STFN_s$, shown in Table 6:

Table 6: fuzzy and crisp percentages

Criterion	Fuzzy	crisp
Leadership	30/76	31/49
Strategy	10/76	11/38
Employee	17/21	17/64
Sharing & resources	21/30	21/55
Processes	19/95	17/94

So according to table 6 sub-hypothesizes 1 was supported:

The ranking of effective criteria on setting EFQM model in an organization (the research case) are the same in crisp and fuzzy approaches.

In order to be comparable, the crisp and fuzzy final importance ratings are tested by spearman correlation coefficient. According to the table 6, with percentage results of crisp and fuzzy ranking, spearman correlation coefficient for these two types of data is 0/9880 so there is a very strong positive correlation between fuzzy and crisp importance ranking and sub-Hypothesizes 1 was supported.

Step 5: Generate Technical Attitude for excellence (HOW_s):
After organization reveals its needs for the products, the company excellence team (experts) should develop a set of (HOW_s) to capture the

organization needs. We arranged fifteen technical attributes for excellence (HOW_s) that is supposed in EFQM guided book.

Step 6: Determine relationships between $WHAT_s$ and (HOW_s):
The experts begin to establish the relationship between the (HOW_s) and the $WHAT_s$, or to examine to what extent each (HOW_s) is related to each $WHAT_s$. So we have 30 matrix that each members of crisp number is shown by (r_{mn}) and fuzzy number by (r^f_{mn}) and "m" is EFQM criterion enabler and "n" is technical attributes for excellence (HOW_s) and "r_{mn}" is the relationship between EFQM criterion and technical attributes. (Table 7)

Table 7: Final relationship matrix between WHATs and HOWs

HOWs / WHATS	Inventory management	Total quality Management	Human resources Management	Knowledge Management	Technology Management	Information management	Energy Management	Project Management	Financial management	Change Management	Customers relationship M	Supply chain Management	Business process management	Strategic Management	Production Management
Leadership	5/7192	6/1828	7/0922	4/8919	5/6836	5/9855	5/427	7/8095	6/102	5/4306	5/9095	5/6447	6/7059	7/1916	6/609
Strategy	5/9893	6/6426	5/3633	5/6483	6/6384	5/9893	6/468	7/3695	6/225	5/7639	6/5562	5/9484	6/2932	7/3438	6/896
Employee	4/6481	5/8363	5/5005	6/2254	5/223	5/6114	5/024	6/5951	6/262	5/9855	6/5993	5/09122	5/8267	5/1006	5/954
Sharing & resources	4/8996	5/0579	5/7927	5/8672	6/4266	5/6483	5/500	7/0393	6/688	5/4629	6/5175	5/9095	6/03512	6/076	5/245
Processes	6/3509	5/3267	5/9114	6/2663	6/4266	6/3887	6/642	7/5651	6/102	6/5134	5/7228	6/349	6/03716	6/422	6/658
sum	27/6071	29/0463	29/6601	28/899	30/398	29/623	29/06	36/378	31/38	29/156	31/305	28/9428	30/8980	32/134	31/36

Step 7: Determine initial Technical Rating of HOWs:

According to the $WHAT_s$ final importance ratings and the relationship values between HOW_s and $WHAT_s$, the HOW_s initial technical ratings can be computed usually through the simple additive weighting (SAW) formula ($initialrating = \sum W_m \times r_{mn}$).

Step 8: Conduct Technical competitive analysis & set technical performance goals for HOW_s:

Now turn to technical competitive analysis which is to find and establish competitive advantages for Joundy Shapoor through comparing all the company's similar products in terms of their technical performance on

the 15 identified HOWs. This information forms a technical comparison matrix. So, applying entropy method to this matrix in the same manner as in excellence competitive analysis (Step 3), technical competitive priority ratings can be obtained for Joundy Shapoor on the 15 HOWs

Step 9: Determine final technical ratings of HOWs:

This is the last step of HOQ model. Integrating the initial technical ratings, technical competitive priority ratings and improvement ratios of HOW_s and also the final importance rating of weights should be multiplied and computed the final crisp and fuzzy numbers of technical attributes (HOW_s). (Table 8)

Table 8: Crisp and fuzzy technical ratings of the 15 HOW_s

Technical Attributes (HOWs)	Crisp	Fuzzy
Business process management	0/5305810	0/5275707
Strategic management	0/5494936	0/547716
Production management	0/530751	0/5322308
Supply Chain Management	0/4902472	0/4917014
Customer relationship Management	0/5274344	0/5291439
Change Management	0/4204019	0/4232004
Financial Management	0/5332682	0/5330812
Project Management	0/6237918	0/6212236
Energy Management	0/4161009	0/4205837
Information Management	0/5033943	0/5038789
Technology Management	0/5106055	0/5140818
Knowledge Management	0/4821601	0/4872539
Human Resources Management	0/5206740	0/5121107
Total Quality Management	0/4913527	0/4918715
Inventory Management	0/4675164	0/4692342

So according to table 8 sub-hypothesize 2 was supported:

The ranking of effective management tools on setting EFQM excellence model in an organization (the research case) are the same in crisp and fuzzy approaches.

In order to be comparable, the crisp and fuzzy final importance ratings are tested by spearman correlation coefficient. According to the table 8, with percentage results of crisp and fuzzy ranking, spearman correlation coefficient for these two types of data is 0/9983. So there is a very

strong positive correlation between fuzzy and crisp importance ranking and sub-hypothesizes 2 was supported. The main hypothesizes of this study "There is meaningful statistical relation between 15 management tools and 5 enabler criteria of EFQM in Joundy Shapoor Company". can be break down into the 75 hypothesizes that show the meaningful statistical relation between 15 management tools and 5 enabler criteria of EFQM. Using the useful management tools that are relevant to the organization's needs for excellence has become so important. By choosing and applying the best management tools among too many management tools, companies can improve their performances and then increase customer satisfaction. But for the organizations that adopted excellence models such as EFQM, to improve their performances, selection and choosing best and effective management tools has been a big challenge. (Yousefie et al 2011)

This paper tries to select and choose best and effective management tools that help Joundy Shapoor Company to achieve excellence. It means that if the case study chooses the best and effective management tools it can be an excellence company in EFQM model. So, here, we try to accept the most meaningful statistical relation between 15 management tools and 5 enabler criteria of EFQM in Joundy Shapoor Company. Therefore based on the relevant computations, from 75 hypothesizes, 28 hypothesizes accepted and 47 ones rejected and these results gain for Joundy Shapoor Company:

1- Leadership has the most meaningful statistical relation with Project management, Strategic management, Total quality management, production management, and Business process management.

2- Strategy has the most meaningful statistical relation with Project management, Strategic management, Total quality management, Technology management, and Energy management

3- Employee has the most meaningful statistical relation with Customer relation management, Change management, Information management.

4- Sharing & resources has the most meaningful statistical relation with financial management and Technology management.

5- Process has the most meaningful statistical relation with Supply chain management, Change management, Production management, Project management, Energy management, Technology management, Information management, Knowledge management and Inventory management.

4. Conclusions

This study has addressed the applicability of QFD in the organizational excellence context. More specially rank viable EFQM excellence criteria and the management tools that a firm can undertake to improve excellence performances. Moreover, fuzzy logic has allowed well to cope with uncertainties understanding of the relationship between "HOW_s" and "$WHAT_s$". By use of the fuzzy importance percents ranking of EFQM criteria and management tools, the basis for programming and allocating of organization resources for the improving of excellence performances can provide. It is shown in Tables 9 & 10.

Table 9: Fuzzy importance percents ranking of EFQM criteria

Criteria of EFQM	
Leadership	25/3%
Sharing &resource	20/5%
Process	20%
Employee	18/5%
Strategy	15.5%

Table 10: Fuzzy importance percents ranking of Management tools

Management tools	Fuzzy
Project Management	62.12%
Strategic Management	54.77%
Financial Management	53.31%
Production Management	53.22%
Customer relation Management	52.91%
Business Process Management	52.76%
Technology Management	51.40%
Human resources Management	51.21%
Information Management	50.39%
Total quality Management	49.19%
Supply chain Management	49.17%
Information Management	48.73%
Inventory Management	46.92%
Change Management	42.32%
Energy Management	42.06%

The methodology developed could be rightly considered as a useful tool for selecting the most efficient and effective management tools to reach organizational excellence. In a similar manner, the weighted importance of management tools allows the firm to identify the key factors of intervention in order to improve the excellence. Moreover, fuzzy logic has allowed coping with uncertainties and incomplete understanding of the relationship between "$WHAT_s$" and "HOW_s". So the company can improve itself to be excellence in its market.

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