Using Statistical Model in Studying the Effects of Business Excellence Model (EFQM) on Sigma Level of Manufacturing Products

Samira Bagheri[1], Amir Abbas Shojaie[2], Paria Soleimani[3]

[1] MS in Industrial Engineering, Islamic Azad University South Tehran Branch,
[2] Assistant Professor; Ph.D. in Industrial Engineering, Islamic Azad University South Tehran Branch
[3] Assistant Professor; Ph.D. in Industrial Engineering, Islamic Azad University South Tehran Branch

ABSTRACT

A procedure's sigma as a criterion, which shows a procedure's efficiency and effectiveness, has important effects on the efficiency and so does on compatibility of a productive institution; EFQM is an approach based on enduring excellence in all aspects of the process. The present study, considering the goal of modeling and study and analysis of the effects of EFQM on Sigma level of products, focused on the case study of productive procedures of a company which produces medical equipment (patient's vital signs monitor). In so doing, the EFQM enablers criteria were considered as independent variables and the six basics of sigma level as dependent variables; were studied and analyzed based on sampling data. Then through the hypothetical test, the existence or non-existence of a meaningful relation among EFQM enabler criteria and each of sigma level basics was studied according to confirmatory factor analysis method by a software called LISREL. According to the model formed on the suggested conceptual framework based on theoretical concepts, a set of solutions were presented in order to improve the sigma level of products based on EFQM.
KEYWORDS: Sigma level, EFQM excellence model, enabler criteria, modelling, confirmatory factor analysis.

1. INTRODUCTION

Today, the very close and complicated competition among different companies all over the world, makes, the importance of high quality production with desired costs, a vital criteria in companies survival; thus companies think of various tools and approaches to reach this goal.

One of the newest managerial concepts which has become the center of attention in different countries, is organizing business quality models based on which different organizations and institutions are analyzed and compared; and as a result of a competitive environment they try to improve their statuses. The acceptance of organizational quality culture and the interest of managers and experts of industry and services in continuing improvement, has led to an increasing demand for quality systems; the most important of which is EFQM [1]. EFQM model, if used in a proper way, is an influential device that can internalize[organizational concepts and values, formulating and persuading guideline plans, using self-assessment methods, organizational learning, and continuing improvement] in organizations; and is also provides the organizations with understanding the best procedures and doing something in an efficient way.

In other hands, one of the other major approaches to high quality level, is six sigma methodology. Six sigma is indicative of a quality level in which, the faulty production rate of a firm is less than 3.4 in each million fault probability; and thus there is no doubt that the rate of success of each device factor in improving quality, considering its effect on decrease of faulty production will be studied.

In this study, it has been tried to study the effect of development of EFQM on Sigma level of manufacturing process.

In 1991, EFQM model was established and in 1992, the first European Quality Prize was started. Since then, EFQM model was reviewed regularly and updated in order to reflect the best managerial thoughts and approved functions. This model is based on an excellence and includes all aspects of organizational management. Also in all sorts of organizations with different sizes. One of the important characteristics of this model; used to assess organizations' functions; is that it is necessary not only in the field of procedures but also in relation to the results of these procedures. Using this model, we can discover the strong and weak points of an organization and thus these weak ones can be improved. EFQM is based on nine criteria; five of which are enablers and four others, the results. Enablers include the duties of an organization, and the results are the organizations' achievements. Enablers cause results, and results motivate enablers. Enablers are: leadership, policy and strategy, Human Resources, partnership and processes. In addition, results are: customer's results, human resources' results, society results, key performance results.

Until now, extensive research is done through the European Foundation of Quality Management on organization's operation assessment; it can be referred to some of them:

Calvo-Mora et al. (2006) [2] in their study of EFQM enablers tried to analyze the relation among criteria to present a managerial framework for improving quality in higher education; in so doing they studied the literature and experimental methods of Universities in Spain. Testing their hypotheses, they displayed that there is a relation among enablers criteria and thus they emphasize enablers role in reaching organizational high quality. Sharma and Talwar in their research done in

Corresponding author: Samira Bagheri, MS in Industrial Engineering; Industrial Engineering Faculty, Islamic Azad University South Tehran Branch, Iran. sa_ba_8665@yahoo.com

2007, through using questionnaire and analysis, showed the reason for blending organizational high quality model through using Veda philosophy, main focus of which is on value-based leadership which leads to endurable growth; the main key high quality model is the values and procedures [3].

Mavroidis et al. in 2007, based on the collected data derived from structured questions and telephone conversations with representative organizations for National Award, found out that there are different high quality systems according to cultural differences in European countries; they also understood that there is a special tendency in the recent decades which let different national and foreign organizations to cooperate to reach high organizational quality [4].

Klefsjö et al. (2008) [5], through studying the literature and analysis of the present ways, studied the development of quality management, they have focused on beneficiaries management concepts as the main concepts of quality management systems; they believe in the priority of customers and beneficiaries. Concepts such as human rights, global development, saving the environment can be considered. Dashtizadeh (2004) [6] in his/her thesis named "Toward Quality Using EFQM in Civil Engineering Company Farafan" tried to discover the amount of knowledge of the managers of this EFQM model, to introduce different aspects of this model to both managers and human resources to hold assessment sessions and workshops to run this EFQM model, to understand strong points and improvable aspects, and also to calculate the company's score based on a scoring logic. Raeisi et al. (2009) [7] in their research on assessing the function of high quality pattern in Social Security Organization's (Tamin Ejtemaee) hospitals in Tehran, showed that the hospitals reached positive feedback by using holistic management pattern; but the successes they gained was less than described level; and thus it demands a better and more effective relation in their financial, marketing aspects with other provider companies.

Six Sigma was born in 1979 in Motorola. The name and idea of Six Sigma refers to the master quality engineer of Motorola; Achieving quality levels of "Six Sigma" were determined as a five-year strategy [8]. A through definition of six sigma can be summarized under the three following approaches: Six sigma is a managerial philosophy, based on customers need and decrease of fault; decrease in fault equals less cost and increase in producer's validity. The main element of six sigma can be put into dependence basics:

First basic: A true emphasis on the customer
Second basic: Processes
Third basic: Management based on truth and information
Forth basic: Action management
Fifth basic: Unlimited cooperation
Sixth basic: Moving toward quality and resistance to failure [9].

As mentioned, six sigma has been able to attract lots of companies and organization attention in a way that they have used it in their systems. In a report in Forbes magazine, more than %35 of 500 of the best world companies have used this methodology. Also in another study it is indicated that six sigma has been the most satisfying method according to big companies. Among the big companies which have used six sigma we can refer to Kodak, Federal Express, Sony, Toshiba, AMD etc. Among these, the results of this method has been more reported from Motorola, General Electric and AlliedSignal.

Amer et al. (2009) [10] in their article used a collection of six sigma design, Fuzzy logic, for optimization, monitoring and control of order completion process in an international retail factory. They used IDDOV cycle.

Franca et al. (2009) [11] introduced a social and multi-goal model for providing cycle. Its goal was to increase the profit and quality (using six sigma). They gain their goal through decrease in the number of faulty raw parts got from the provider. Gijo and Scaria (2010) [12] using six sigma method and statistical methods, like regression, hypothesis test, Taguchi method, became able to increase the payment efficiency (high efficiency) in an automobile parts producer company from %88 to %100.

Wei et al. (2010) [13] presented a framework based on six sigma DMAIC to guarantee trustable goods in distributing factory process (contactor). This leads to customer's satisfaction and decrease in guarantee fees. A control mechanism for recognizing and eliminating faults is also presented from the very beginning.

This study can be considered in continuation of the former studies.

2. MATERIALS AND METHODS

It seem that quality development can affect sigma level of a procedure, especially special equipment procedures, but such relations and their effects are ambiguous; thus this study tends to test the relation between EFQM and sigma level of manufacturing procedures and analyses different aspects of this effectiveness and finally to answer these questions:

1. Does EFQM have a meaningful/considerable effect on sigma level of manufacturing procedures?
2. What factors in EFQM have meaningful effect on Sigma level of manufacturing procedures?
3. How is the relation priority of these meaningful elements?
4. How are the suggested functional alternatives based on basic motivations chosen?

Considering EFQM enablers as independent variables and dependent basics of Sigma level as dependent variables (Table 1), each relationship would be studied as hypothesis of the study:

Table 1. Definition of independent and dependent variables in suggested model

Variable type	Variable symbol	Variable title	number
dependent	Y_1	True emphasis on customer	1
dependent	Y_2	Emphasis on Processes	2
dependent	Y_3	Management based on Truth and Information	3
dependent	Y_4	Action Management	4
dependent	Y_5	Cooperation and Unlimited Collaboration	5
dependent	Y_6	Moving Toward Quality and Resistance to Failure	6
independent	X_1	Leadership	7
independent	X_2	Policy and Strategy	8
independent	X_3	Human Resources	9
independent	X_4	Partnership	10
independent	X_5	Processes	11

Thus the following methodology is designed:

First step: Designing a theoretical model based on EFQM enablers relationships and dependence basics of Sigma level of products;

Second step: Designing questionnaires and considering all the relations;

Third step: Testing the present hypothesis to check the existence or non-existence of a meaningful relation among EFQM enablers and sigma level basics through using confirmatory factor analysis;

Forth step: Comparing the resulting model to/with the theoretical model;

Fifth step: Defining improving actions related to the effect of EFQM on Sigma level of products;

Considering the fact that the final results of this study has crucial role on the maintenance and improvement of products and is also important to patient's health, the study has practical goals. All through the study to collect information, questions, documents, books, articles, thesis and electronic data base are used especially when it concerns review of the literature; the present study considering its nature and methodology is a descriptive-monitoring study.

2.1. Population and Statistical Sample

Population in this study has been personnel and human resources of Saadat Company (producer of patients' vital signs monitors); including 65 people; thus the study's population is a limited one. To estimate the sample volume Morgan's Table has been used. Thus for a population of 65, sample size 56 has been defined and at last 58 questionnaires were collected for analysis.

In this study, simple accidental sampling is used in which the chance and probability of being chosen in the same all through its population.

2.2 Data Collection

In this study, since the study of dissertations (theses), articles, Latin and Persian books was so necessary, library is used a lot also internet (library method).

The main data collection method in the other phase of the research (the study of EFQM and sigma level of products) is questionnaire (field method).

2.3. Data Analysis

To see if there is a meaningful relation among EFQM enablers and administrative basics of Sigma level, a questionnaire containing 30 questions concerning the history of the topic and interviewing major figures has been designed and it is attempted to be as short and clear as possible. To assess/evaluate each question, a distance measuring scale called Likert is used. To have endurable questionnaire Alpha Cronbach method is used. Alpha Cronbach coefficient, using SPSS software is calculated as 0.86 which is an acceptable coefficient.

Thus it can be concluded that the mentioned questionnaire is endurable. Then, the findings underwent confirmatory factor analysis using LISREL software and after comparing the concluding model with the original theoretical model, some actions for improving sigma level based on EFQM factor were presented.

3. RESULTS

To assess the effectiveness of EFQM on Sigma level; since that enablers lead to results; only the effect of EFQM enablers in relation to Six Sigma basics were evaluated. In so doing, first a suggested conceptual framework based on each EFQM factor definition, and also their sub-factor, their relations with Sigma basics were considered (Fig 1).
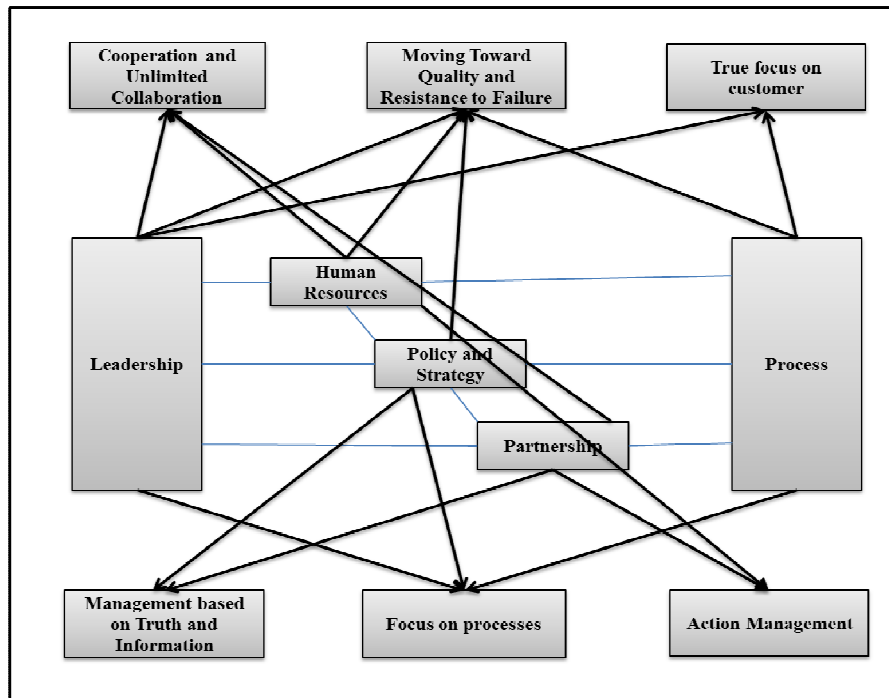
Fig. 1. Theoretical Model of the Effect of EFQM Enablers on Sigma Six Basics

The distributed questionnaires and collected data resulted in a model and based on confirmatory factor analysis the relation among variables of the model was studied. The basic analysis was done by Lisrel 8.8 software and a summary of fit index of the model is available in Table 2.

Table 2. Fit Indices of the Model

Fit	Index Amount	Index
Weak	0.11	RMSEA
Weak	0.000	RMSEA P-Value
Good	1.99	x^2/k
Weak	0.67	CFI
Weak	0.55	GFI
Weak	0.48	AGFI

According to table 2, all fit indices of the model show that the model is not appropriate. Thus according to theoretical model and also the amount of factor weight, some variables (some questions from questionnaire) were omitted/deleted from the model (variable with factor weight less than 0.3. To reach an appropriate model, fit indices for possible and suitable theoretical model for the study is available in Table 3.

Table 3. Fit Indices for Possible Situation of the Model

AGFI	GFI	CFI	x^2/k	RMSEA P-Value	RMSEA		Model
0.69	0.80	0.83	1.58	0.11	0.08	Index Amount	**Model 1**
Weak	Weak	Weak	Good	Good	Good	Fit	
0.70	0.79	0.87	1.52	0.21	0.069	Index Amount	**Model 2**
Weak	Weak	Weak	Excellent	Excellent	Excellent	Fit	
0.67	0.77	0.79	1.61	0.048	0.087	Index Amount	**Model 3**
Weak	Weak	Weak	Good	Weak	Weak	Fit	
0.70	0.80	0.85	1.58	0.12	0.079	Index Amount	**Model 4**
Weak	Weak	Weak	Good	Good	Good	Fit	
0.67	0.76	0.84	1.61	0.077	0.08	Index Amount	**Model 5**
Weak	Weak	Weak	Good	Good	Good	Fit	
0.65	0.75	0.79	1.64	0.021	0.091	Index Amount	**Model 6**
Weak	Weak	Weak	Good	Weak	Weak	Fit	
0.84	0.74	0.82	1.62	0.023	0.088	Index Amount	**Model 7**
Weak	Weak	Weak	Good	Weak	Weak	Fit	

As far as it is seen, CFI, GFI and AGFI indices aren't suitable for all models but based on the two indices of RMSEA and normed Chi-square, it can be concluded that the considered models have good fit. Also these 2 indices are better for

model 2 than other models. Thus the best model for this research is model 2. Figure 2 shows factor weight coefficient of the above model.
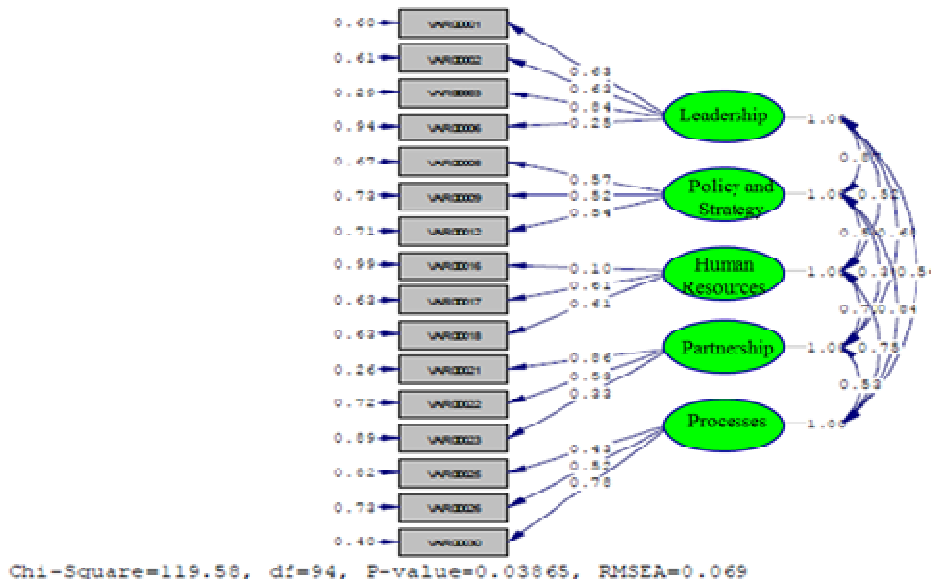

Chi-Square=119.58, df=94, P-value=0.03865, RMSEA=0.069

Fig. 2. Final Model of the Effect of EFQM Enablers on Six Sigma Basics

Table 4 shows standard coefficients of factor weight leadership and administrative variables of Sigma level.

Table 4. Factor Weight Coefficient of Leadership Criterion

P-Value	T test	Factor Weight	Variables
0.000	4.92	0.63	**True Emphasis on Customers**
0.000	4.87	0.63	**Emphasis on Processes**
0.000	7.06	0.84	**Management Based on Truth and Information**
0.077	1.79	0.25	**Moving Toward Quality and Resistance to Failure**

As it is shown in the table, the P-value in variables of true emphasis on customers, emphasis on processes, management based on truth and information are less than 0.05, thus with assurance level of 0.95; the hypothesis regarding that the above variables' dependence equals to zero, is rejected with EFQM leadership. Thus among the above variables with EFQM leadership, there is a meaningful dependence. Also because of P-value the following variables: moving toward quality and resistance to failure that is more than 0.05 and its factor weight is less than 0.3, it can be concluded that there is not a meaningful dependence between 'moving toward quality and resistance to failure' and EFQM leadership.

Table 5 indicates standard coefficient of factor weight for policy and strategy and administrative variables of Sigma level.

Table 5. Factor Weight Coefficients of Policy and Strategy Criterion

P-Value	T test	Factor Weight	Variables
0.000	4.15	0.57	Emphasis on Processes
0.000	3.75	0.52	Management Base on Truth and Information
0.000	3.89	0.54	Moving Toward Quality and Resistance to Failure

As seen in the table, the P-value for all the following variables; emphasis on processes, management based on truth and information and moving toward quality and resistance to failure are less than 0.05, thus with the assurance level of 95%, the hypothesis regarding that the above variables' dependence equals to zero for EFQM policy and strategy is rejected. Thus there is a meaningful dependence among above variables and EFQM policy and strategy. Considering the fact that factor weight of 'emphasis on processes' variable is 0.57, and the fact that this is more than other variables, the dependence of the above variable with EFQM policy and strategy is more than other variables.

Table 6 indicates standard coefficient of factor weight of human resources with administrative variable of Sigma level.

Table 6. Factor Weight Coefficients of Human Resources Criterion

P-Value	T test	Factor Weight	Variables
0.53	0.63	0.10	Action Management
0.000	4.01	0.61	Cooperation and Unlimited Collaboration
0.000	4.02	0.61	Moving Toward Quality and Resistance to Failure

As concluded from the table, the P-value for the following variables: cooperation and unlimited collaboration and moving toward quality and resistance to failure, are less than 0.05, thus there is dependence among above variables and EFQM human resources; considering P-value of 'action management' which is more than 0.05, and factor weight of less than 0.4, it can be concluded that there is not a meaningful relation between this variable and EFQM human resources.

Table 7 indicated standard coefficient of factor weight of cooperation with other administrative variables of Sigma level.

Table 7. Factor Weight Coefficients of Partnership Criterion

P-Value	T test	Factor weight	Variables
0.000	6.13	0.86	Management Based on Truth and Information
0.000	3.82	0.53	Action Management
0.02	2.33	0.33	Cooperation and Unlimited Collaboration

As seen in the table, the P-value for all the following variable: management based on truth and information, action management, cooperation and unlimited collaboration are less than 0.05, the hypothesis regarding that the above variables' dependence equals to zero is rejected according to EFQM partnership criterion. Therefore, there is a meaningful dependence among above variables and EFQM partnership criterion and also considering the fact that the amount of factor weight for 'management based on truth and information' variable is 0.86 and is more than other variables; the mentioned variables' dependence with EFQM partnership criterion is more than other variables.

Table 8 shows standard coefficient of factor weight of procedure criterion with administrative variables of Sigma level.

Table 8. Factor Weight Coefficient of Processes Criterion

P-Value	T test	Factor Weight	Variables
0.004	2.96	0.43	True Emphasis on Customer
0.000	3.7	0.52	Emphasis on Processes
0.000	5.53	0.78	Moving Toward Quality and Resistance to Failure

As shown in table 8, the P-value for all the variables of: true emphasis on customer, emphasis on Processes and moving toward quality and resistance to failure are less than 0.05, thus with the assurance level of 95%, the hypothesis that the above variables' dependence equals to zero is rejected by EFQM procedures; in other words, there is a meaningful dependence among the above variables and processes criterion. Because factor weight of 'moving toward quality and resistance to failure' criterion is 0.78 and is more than other variables, dependence of the above variable with EFQM processes is more than other variables.

4. DISCUSSION

4.1. The Study of the Relationships of EFQM Enablers with Six Administrative Basics of Sigma Level

According to the model, the results show that 'leadership' criterion has a meaningful dependence with basics of 'management based on truth and information', 'emphasis on customer', and 'emphasis on processes'. While there is not such a relationship among 'leadership' with basics of 'moving toward quality and resistance to failure'; and there is no meaningful dependence among them which is of course against the suggested model. Also the findings do not show any relation between 'leadership' and 'cooperation and unlimited collaboration' (opposite to suggested model).

'Policy and strategy' criterion with 'emphasis on processes', 'moving toward quality and resistance to failure', and 'management based on truth and information' have the same meaningful dependence, and thus validate the suggested model.

According to the results, 'human resources' criterion has an equal dependence with 'cooperation and unlimited collaboration' and 'moving toward quality and resistance to failure'. While, against the suggested model, there is not a meaningful relation between 'action management' and EFQM human resources.

'Partnership' criterion has an excellent dependence with management based on 'truth and information', and it also has a meaningful dependence with 'action management'. This criterion has a weak meaningful relation with 'cooperation and unlimited collaboration' criterion.

'Processes' also has meaningful dependence with 'moving toward quality and resistance to failure' and then 'emphasis on processes' criterion. It must be considered that dependence between this criterion and 'emphasis on customer' is weak. In the following section a series of solution are presented in order to improve the relations.

4.2. Necessary Actions for Increasing Sigma Level of Products based on EFQM Model

Necessary Action in Relation to 'Leadership' Criterion: creating a mechanism to form a team and leadership methods and their effectiveness, enabling chief managers to have appropriate relationships, designing common improvement activities (between and providers and contractors), prioritizing improving activities in the company, assessment and reviewing approaches to update policies and strategies, measuring learning and improvement in the company, holding continuous and structured sessions with providers and using their views for improvements.

Necessary Actions in Relation to 'Human Resources' Criterion: Assessing individual and team-work function in the company, being supportive to creative behavior in the company, creating suitable communication channels to meet all the existing needs of the organization.

Necessary Actions in Relation to 'Partnership' Criterion: Exact Planning for outsourcing and also through study before and after rendering and calculating the rate of effectiveness and value added for the customers, using providers' views and suggestions to improve procedures, defining policies and strategies related to copartners affected by company's major strategies, evaluating collaborating approaches to company's providers.

Necessary Actions in Relation to 'Processes' Criterion: Strengthening communicative channels with customers, improving creative management and creativity in the company's relationships with emphasis on procedures to create value added, informing emphasis on procedures about the realizable value of products.

5. Conclusions
5.1. Answering the Study's Major Questions

According to the confirmatory factor analysis results gained from the model it has been approved that EFQM enabler criteria have a meaningful relation with six administrative basics of Sigma level.

This study only evaluates the effect of EFQM enablers and all had effect on sigma level of manufacturing procedures. Considering the calculations, the prioritization of the criteria would be as follows: leadership, procedures, cooperation, policy and strategy, and human resources. Suggested operational alternatives have been suggested based on EFQM model.

5.2. Further Suggestions

Concerning the carried out research some suggestions can be made for researchers who are interested in working on quality management area. A set of suggestions are presented here:
1. The study of effects of EFQM results on the Sigma level of products.
2. Prioritizing the effectiveness rate of presented solutions in an organization.
3. Using various statistical methods different from the ones used in here.
4. Doing similar researches in other organizations to compare the results.
5. Studding other evaluating models on Sigma level of products.

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