Integrating DEA and EFQM Model for Performance Evaluation With a Case Study in the Automobile Industry

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Abstract

The European Foundation Quality Management is one of the models which deal with the assessment of function of an organization using a self-assessment for measuring the concepts some of which are more and more qualitative. Consequently, complete understanding and correct usage of this model in an organization depend on the comprehensive recognition of that model and different strategies of self-assessment. The process of self-assessment on the basis of this model in an organization needs to use the experienced auditors. This paper reports a survey and case study research outcomes on the application of Data Envelopment Analysis (DEA) to the ranking method of European Foundation for Quality Management (EFQM) Business Excellence Model in Iran's Automotive after assessment. A question which is raises is whether the EFQM model can be combined with a mathematical model such as DEA in order to generate a new ranking method. The developed model of this paper is simple. However, it provides some new and interesting insights. The paper assesses the usefulness and capability of the DEA technique to recognize a new scoring system in order to compare the classical ranking method and the EFQM business model. The research indicates that the DEA approach is a reliable tool to analyze the latent knowledge of scores generated by conducting self-assessments.

Keywords: European Foundation Quality Management, Data Envelopment Analysis, self-assessments, Benchmarking, Performance.

1-Introduction

The model of the European Foundation for Quality Management (EFQM) has been widely recognized as a representative theory to improve traditional total quality management (TQM) by expanding the narrow quality-oriented concept into a holistic management concept. The award aims to develop awareness of the importance of quality in the intensified global market (Evans and Lindsay, 2005; Andersen et al., 2003).The model is an integrative business system that covers all management activities composed of input, process, and output (Black and Crumley, 1997; Seghezzi, 2001). The model's important assumption is that excellent performances (e.g. customer and financial performance) are derived through five enablers (e.g. leadership, people and processes). On the basis of the premise, the model is divided into two areas – i.e. enabler and results and allocates balanced weights (50-50) between the two areas. The evolution of the EFQM model inquiry should be based on various research topics and methodologies. A number of papers, for instance, have been focused on limited research topics, namely performance measurement and the EFQM model's paradigm (e.g.Bititci,1995). The EFQM model has been explored in terms of different tools for systematic performance management (Wongrassamee et al., 2003), self-assessment (Tarı´, 2006), teamwork development (Castka et al., 2003), integration issues (Davies, 2008), and benchmarking (Castka et al., 2004). Among them, self-assessment is regarded as one of the most interesting topics for both researchers and companies implementing the EFQM model (Hillman, 1994; Samuelsson and Nilsson, 2002; Black and Crumley, 1997). This is because the self-assessment enables organizations to identify their strengths and areas for improvement (Ritchie and Dale, 2000; Samuelsson and Nilsson, 2002;Wilkes and Dale, 1998; Ford et al., 2004; Hartley and Downe, 2007).

Based on the outcomes of the self-assessment, organizations can gain more objective and holistic views by comparing their results with other organizations. At the operational level, the outcomes also encourage managers not only to determine which key areas should be managed, but also to monitor a variety of activities in a controlled manner. However, some organizations derive little benefit from self-assessment processes (Conti, 2001). This could be due to the problems that may arise, such as: the lack of support by the quality department; and the difficulty in implementing the improvement actions (Ritchie and Dale, 2000). Developing all the stages in the process might be a way to ensure success.

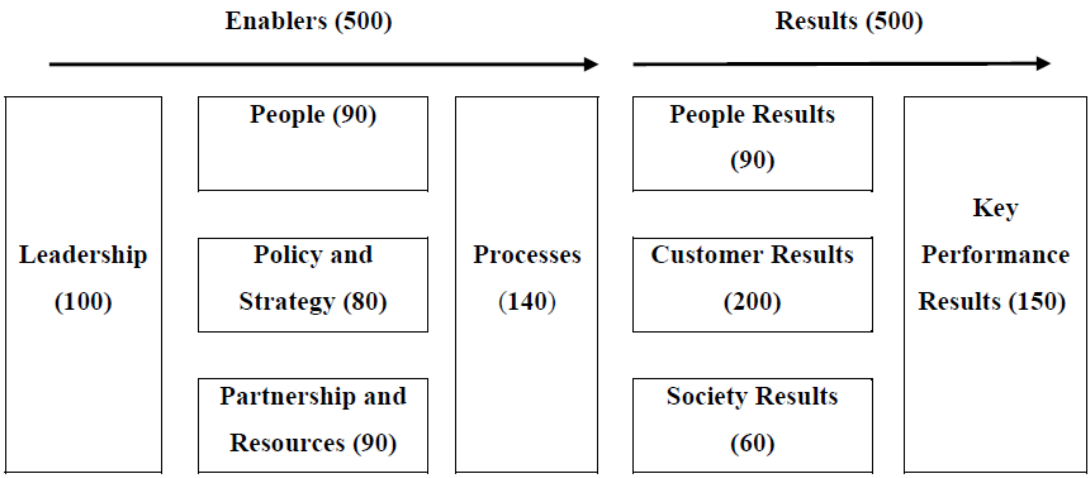
Data Envelopment Analysis (DEA) is a particular formulation (Charnes et al., 1978) of a well-proven quantitative technique already applied in a variety of commercial as well as not for profit contexts to help with issues in resource analysis and allocation (Sarrico et al., 1997; Doyle and Green, 1991). DEA is used to measure the aggregate, or composite, relative performance of organizational decision making units (DMUs). It is especially useful where direct comparison between DMUs is made difficult by the presence of multiple inputs and outputs, perhaps using different metrics, and where the precise nature of the input/output conversion relationships are either not known or not easily identified. DEA assessments can rank order DMUs; elaborate on the specific performance of any individual DMU; identify exemplars for those DMUs whose performance can be improved; and determine targets for poor performer DMUs

based on the proven performance of the exemplar set (Charnes et al., 1978) developed data envelopment analysis (DEA) as a 9methodology (CCR model) aimed at evaluating the relating efficiency of decision making units (DMUs) solely on the basis of their observed performance. In recent years, a growing number of researchers have looked into ways to incorporate judgment into DEA. (Donnelly, 2000) applied DEA in re-ranking of a number of organizations based on the EFQM approach. (Khan et al., 2008) applied DEA model to evaluate quality assessment of technical education system in India using two types of models known a constant return to scale (CRS) and variable return to scale (VRS).(Wang et al., 2009) have proposed a fuzzy DEA model for ranking performances of eight manufacturing enterprises in China. However, the latent knowledge behind the scores was not analyzed to draw a road map showing the companies how to plan the improvement activities and set actual targets for each enabler. By using DEA application validity as a new method of ranking, usage of the method in other sectors and different organizations is an interesting issue. We argue that current studies on the EFQM model have missed the model's fundamental premise: emphasizing comprehensive exploration and implementation. The main aim of this investigation is to propose an integrative approach of DEA and EFQM for quantitative assessment of performance in order to achieve more realistic results. In addition, the impact of changing each of the inputs on the efficiency of organization is studied by sensitivity analysis.

For this purpose, in the following the concept of EFQM model and associated methodological issues are briefly introduced. The subject of DEA is also demonstrated. Respectively, a new integrative approach is proposed and analyzed in an automobile maker company in Iran. Finally, the findings are discussed and major conclusions are made.

2-EFQM

The main purpose of the EQA was recognizing the organizational excellence in European companies since 1991. (Westlund, 2001) argued that the EFQM Excellence Model is a framework behind this award and it has clearly become the most commonly applied model in Europe for TQM. The EFQM Excellence Model comprises nine criterions grouped under five "enablers" criteria that include: leadership, policy and strategy, people, partnerships, and resources and process and also, four "results" criteria that includes: customer results, people results, society results, and key performance results. The enablers stand for how the organization operates, and the results focus on the achievements towards organizational stakeholders, those who have an interest in the organization, and how they can be measured and targeted (Fig. 1). Each criterion is divided into several sub-criteria and each sub-criteria is exemplified with various "guidance points" that explain what the organization must do to develop the criteria.



Figuare1.EFQM Model

The EFQM Excellence Model, like other quality award models such as the Malcolm Baldrige National Quality Award in USA or Deming Prize in Japan, is based on self assessment. (Hillman, 1994) mention that self-assessment means a comprehensive and regular review of an organization's activities and results alongside the criteria of the model. Porter and Tanner argued that undertaking a self-assessment process against the EFQM Excellence Model provides an objective, complete measure of strengths of an organization and improvement areas, and gives rise to the establishment and implementation of action plans, integrated in business planning. (Van der Wiele et al.,2000) mention that the self-assessment process also allows a methodology to be adopted that will assess progress towards excellence on a regular basis by providing a comparison of scores from assessment to path the real achieved improvement. Since the EFQM Excellence Model is a non-prescriptive framework, self assessment can be conducted by using a variety of tools such as: questionnaires, workshops, award simulation and achievement matrix. But the EFQM Excellence Model has other benefits apart from those derived from self-assessment.

2-1- Modified EFQM : The case of Iran's car maker companies

The Excellence Model was introduced to Iranian companies in 2000 and the first countrywide assessment of the EFQM, as a selected framework of Iranian authorities, was conducted in 2002. The most profound impact of the Quality Management and Excellence Practice on organizational performance has been in the Iranian Steel making and Automotive Industry. Mentioned industries have clearly proved the possibility of old manufacturing businesses revitalization and it will continue showing the improvements in quality and productivity. Recently, Iranian automotive companies have

started action plans on assessing their affiliated companies in order to improve productivity and launch TQM, using EFQM tools.

3- **Data Envelopment Analysis**

Data Envelopment Analysis (DEA) is relatively a new "data oriented" approach for evaluating the performance of a set of similar entities called Decision Making Units (DMUs) which converts multiple inputs into multiple outputs (Zhu, 2002). The definition of a DMU is generic and flexible. Since DEA in its present form was firstly introduced in 1978, various researchers have rapidly recognized that it is an excellent and easily used methodology for modeling operational processes for performance evaluations. For example, Zhu provides a number of DEA spreadsheet models that can be used in performance evaluation and benchmarking. The empirical orientation of DEA and the absence of a need for the numerous previous assumptions that accompany other approaches such as standard forms of statistical regression analysis have results in its use in a number of studies. DEA is used in the efficient frontier estimations in the governmental and nonprofit sector, the regulated sector, and the private sector. (Cooper and Rhodes,1978) described DEA as a 'mathematical programming model applied to observational data that provides a new way of obtaining empirical estimations of relations such as the production functions and/or efficient production possibility surfaces that are cornerstones of modern economics'. Earlier, Farrell motivated the need of developing better methods to evaluate the productivity. He argued that attempting to solve the problem usually produces careful measurements which are also very restrictive because they failed to combine the measurement of multiple inputs into any satisfactory overall measure of efficiency. The initial DEA model, as originally presented in Charnes, Cooper, and Rhodes (CCR), was built on the earlier work of Farrel. Allowing the applications to a wide variety of activities, they used the term Decision Making Units (DMU) to refer to any entity that is to be evaluated in terms of its abilities to convert inputs into outputs .They assume that there are n to be evaluated which each one consumes varying amounts of m different inputs to produce S different outputs. Specifically consumes amount of input i and produces amount of output r .Firstly, they introduce the "ratio-form" of DEA in which the ratio of outputs to inputs issued to measure the relative efficiency of the = to be evaluated relative to the ratios of all of the j =1,2,..., n . The efficiency of a specific can be evaluated by the ''BCC model'' of DEA as introduced in (Banker et al., 1984) which we present in ''envelopment form'' as follows:

Minim (1)

Subject to

(2)

(3)

(4)

Figuare2.BCC Model

The dual (multiplier) form of the (BCC) model represented in Figuare (2) is obtained from the same data which are then used in the following form Figuare (3):

Maximize z (1)

Subject to (2)

(3)

Figuare3.BCC Model

The form of the EFQM Model of Business Excellence permits a relatively simple analysis of the performance of a DMU in terms of the relationship between its inputs (leadership, policy and strategy, human resource, resources, and participations and process) and its results (customer results, human results, society results and key performance results) assessed by awarding a percentage score to each Enablers and Results category, the overall performance of a DMU is measured by the EFQM model in a simple, but pre-determined, weighted aggregation of each of the scores across all the nine elements. An alternative perspective is to regard the Enablers as inputs and allocate an "opportunity cost" of 100 minus the EFQM percentage score reflecting the improvement that might still be achieved in each of the five elements making up the Enablers set. The percentage scores which the DMU attracts in its Results elements, in this perspective, might be regarded directly as the outputs of the DMU. The aim then would be to minimize the weighted aggregate of the input "costs" to achieve a maximum weighted aggregate output score.

6- Methodology and Findings

The form of the EFQM Model of Business Excellence permits a relatively simple analysis of the performance of a DMU in terms of the relationship between its inputs (leadership, policy and strategy, human resource, resources, and participations and

process) and its results (customer results, human results, society results and key performance results) assessed by awarding a percentage score to each Enablers and Results category, the overall performance of a DMU is measured by the EFQM model in a simple, but pre-determined, weighted aggregation of each of the scores across all the nine elements. An alternative perspective is to regard the Enablers as inputs and allocate an "opportunity cost" of 100 minus the EFQM percentage score reflecting the improvement that might still be achieved in each of the five elements making up the Enablers set. The percentage scores which the DMU attracts in its Results elements, in this perspective, might be regarded directly as the outputs of the DMU. The aim then would be to minimize the weighted aggregate of the input "costs" to achieve a maximum weighted aggregate output score.Each year companies in automotive industry assess their affiliated companies by using the EFQM Excellence Model. After assessing up to 46 companies and defining improvement projects based on assessment results and scores, it is important that companies must benchmark the best practices across the Group companies. It is essential that Holding Company must monitor the use of an appropriate performance measurement system on a regular basis that follows: what activities are going well?, Which have stagnated?, What needs to be improved?, and what is missing?. Since the launch of the EFQM Model in 1991, thousands of European organizations have used the model as a framework for assessing their performance. But to date, little use has been made of the criteria underpinning the model together with the data collected to build and develop decision models and associated analysis tools for supporting the self-assessment process. In this paper, we have used DEA approach in order to build a decision model that helps the managers to goal setting for each criteria of EFQM business model. The Data shown in Table1 are the percentage scores for each of the nine elements, five Enablers criteria as Inputs and four Results criteria as Outputs. Data of the Business Excellence Model for 46 companies are assessed by the Assessment Teams.

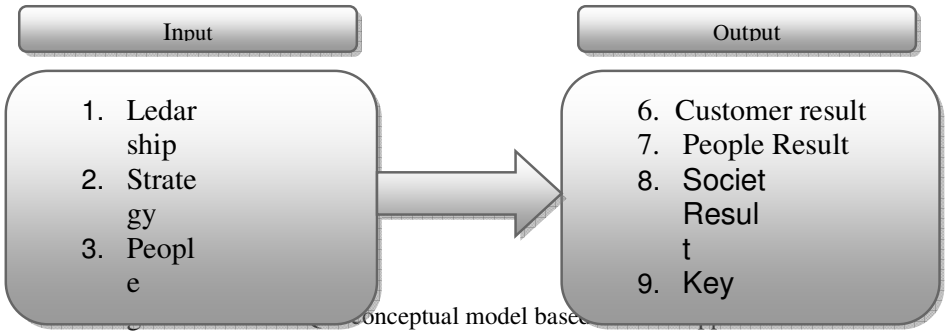
Table 1.Percentage for each criteria in Automotines

Company Number.	Leadership	Strategy	Human Resources	Resources	Processes	Customer Result.	Human Result.	Society Result.	Key Performance.Result.
1	40.2	38.1	49.4	48.2	41	30.3	47.11	25.2	40
2	23	13.8	28	29	15	21.25	12.5	11.3	32.5
3	24	18.8	24	30	30	10	16.3	10	22.5
4	18	18.8	30	24	50	25	32.5	11.8	22.5
5	26.3	22.4	32.9	32.8	34	21.6	27.1	14.5	29.4
6	20.6	23.8	16.5	24.6	22	17	7.25	5.9	12.3
7	23	23.8	14	15	24	15	6.2	5	25
8	30	36.3	31	33	32	15	16	8.8	30
9	23	17.5	22	21	29	10	15	10	15
10	19	16.5	16.5	21	24	20	15	8.3	24
11	30	23	29.8	33.5	38	29.4	32	14.7	34.7
12	25	20	25	28	29	21.25	16	17.5	30

13	16	22.5	17	18.9	19	13.5	10	10	10.8
14	16	8.8	14	18	20	10	29	7.5	10
15	11	10	16	19	18	15	15	15	15
16	21	17.5	27	28	32	11.25	26	13.8	27.5
17	20	18.8	15	17	21	15	11	7.5	27.5
18	21	21.3	30	23.3	30	28.5	30	20	30
19	22	23.8	27	30	25	23.5	27	5	25
20	14	11.3	14	16	23	15	25	10	17.5
21	27	26.3	29	28	31	16.25	21	17.5	37.5
22	15	15	20	15	20	20	15	5	15
23	18.8	20.6	27.5	29.3	30	22.8	14	14.7	26.9
24	21	16.8	19.6	21.2	22	13	13	8.8	20
25	15	12.5	17.1	20	17	5.7	5	8.7	10
26	13	10	17.8	13.3	19	10	10	15	10
27	25	20	25.6	20	30	5	6	5	10

4.1. The Mathematical Modeling (DEA Model)

In the paper has designed a one-year EFQM assessment program for about forty twenty seven companies. The companies taken part in our analysis are from different business sectors but almost in automotive company. The selected assessment teams for the process consist of ten teams of four people with different expertise. The formats and the criteria have been reviewed by teams. To calibrate the results, all teams have analyzed a case study and all assessments have been compared with the base report. In order to make a mathematical model based on the relationship between Enablers and Results criteria in the EFQM business model, we used DEA approach as shown in Fig.4.



onceptual model base

5. Result

In this paper has been used DEA Frontier software to solve the EFQM Conceptual BCC Model Based on DEA Approach. But in DEA model, the smaller inputs are, the more favorable they will be; thus, we reverse the enablers scores. As shown in Table 2, the DEA approach has resulted a new ranking that can be compared with the classical EFQM ranking. One can easily see that the DEA ranking approximately confirms the EFQM ranking. For example, the company No.1 which its EFQM score was 394 and

has gained the first position among other forty six companies, has also gained the maximum efficiency (100%) in the new ranking. But in some cases the results show little changes in ranking. For example, the company No. 18 with the EFQM score of 269 has gained the 4th position but the 10th in the new ranking.

Table 2.Comparison of EFQM Results with DEA Results in Automotive's Group Companies

Company Number	EFQM score	EFQM rank	DEA score	DEA rank
1	394	1	100%	1
2	216	11	60.16%	14
3	203	12	71.28%	7
4	271.6	3	100%	1
5	271.3	4	80.03%	4
6	170	17	62.47%	13
7	177	15	62.47%	13
8	256	6	95.28%	2
9	178	14	68.67%	12
10	197	13	56.81%	16
11	307	2	89.91%	3
12	242	7	69.52%	11
13	152	21	59.06%	15
14	145	23	47.42%	20
15	151	22	43.16%	23
16	225	10	74.19%	6
17	170	17	51.03%	19
18	269	4	70.05%	10
19	239	8	62.47%	13
20	167	18	52.05%	18
21	261	5	74.55%	5
22	166	19	47.10%	21
23	236	9	70.98%	9
24	175	16	53.47%	17
25	119	26	41.49%	24
26	128	25	43.91%	22
27	157	20	71.56%	8

6. Discussion

In this paper have noted in previous sections, one of the main objectives of the Automotive's Group Corporation (Holding Company) is to prepare a sound approach to share the knowledge, experiences and institutionalization of the benchmarking culture among the companies. The problem of the executive managers in Automotive's Group is that after assessing the companies with the use of the EFQM approach, they do not know how to design a road map so that every company can simply determine the best

practice among companies based on the nine criteria of the EFQM Business Model. The design of a mathematical model with applying DEA Methodology helps the managers to remove this obstacle. We solve Envelopment Form Model to determine benchmark companies. As shown in Table3, we summarized the data for company No.3 The data in "benchmark company" column is taken from the solution of the DEA model revealing that that the company No.3 the criterion of leadership must benchmark the company No.1and so on. With this ability gained from the mathematical modeling with the use DEA methodology, the managers can propose solutions to companies in order to benchmark based on each criterion.

Table 3.Data Related to Company No.3

Criteria	Target Score	Real Achievement	Bench mark	Slack
Leadership	34.14	24	1	0.00041
Strategy	33.19	18.8	1	0.00779
Human Resources	45.19	24	1	0.00757
Resources	42.09	30	1	0
Processes	42.09	30	1	0
Customer Result.	29.54	10	1	19.53707
Human Result	45	16.3	1	28.70690
Society Result	23.27	10	1	13.27108
Key Performance.Result.	37.48	22.5	1	14.98089

7. Conclusions

In this conceptual-mathematical model, I have shown that the DEA mathematical model can be combined with conceptual EFQM Business Excellence Model to produce an optimal ranking as a new ranking based on the EFQM score and help the benchmarking process. This paper reports finding of a survey and case study research on the application of the DEA to the ranking method of EFQM Business Excellence Model in Iran's Automotive Industry. This paper assesses the usefulness and power of the DEA technique to recognize a new scoring system in order to compare the classical ranking method with the EFQM business model. In this paper used this method to identify meaningful exemplar companies for every criterion of the EFQM model and then design a road map based on the realistic targets in each criterion which is currently being achieved by exemplar companies. The research indicates that the DEA approach is a powerful tool to analyze the latent knowledge of the scores generated from the conducting self assessments. Finally, we used the research results in order to draw a road map based on the benchmarking concept. In this survey, we assumed that each criterion in the EFQM Business Excellence Model has an equal importance for each

company. In some situations, this assumption is unrealistic. Since the degrees of importance of the nine criteria are different for one company in comparison with another one, we need to design a mathematical model that recognizes the different weights.

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