AVAILABLE ONLINE AT IJO.IAURASHT.AC.IR

IRANIAN JOURNAL OF OPTIMIZATION

Volume 3, issue 1, Winter 2011,201-219
Research Paper

Islamic Azad University
Rasht Branch

The Application of Data Envelopment Analysis Methodology to Improve the Benchmarking Process in the EFQM Business Model

(Case Study: Automotive Industry of Iran)

K. Shahroudi*

Department of Industrial management, Islamic Azad University, Rasht branch

*Correspondence E-mail: K. Shahroudi,shahroudi@iaurasht.ac.ir

Online version is available on: www.ijo.iaurasht.ac.ir

Abstract

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 Industry and improving benchmarking process after assessment. Following the global trend, the Iranian industry leaders have introduced the EFQM practice to their supply chain in order to improve the supply base competitiveness during the last four years. 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 and develop or facilitate the benchmarking process. 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. We used this method to identify meaningful exemplar companies for each criterion of the EFQM model then we designed a road map based on realistic targets in the criterion which have currently been achieved by exemplar companies. The research indicates that the DEA approach is a reliable tool to analyze the latent knowledge of scores generated by conducting self-assessments. The Wilcoxon Rank Sum Test is used to compare two scores and the Test of Hypothesis reveals the meaningful relation between the EFQM and DEA new ranking methods. Finally, we drew a road map based on the benchmarking concept using the research results.

Keywords: Data Envelopment Analysis; EFQM Excellence Model; Wilcoxon Rank Sum Test; Benchmarking; Road Map.

1. Introduction

Regarding the recent dispute, the current enablers and results criteria of the European Foundation for Quality Management (EFQM) Business Excellence Model assess organizational quality performance effectively. However, there are different opinions about the actual values related to individual element weightings. It is more significant when companies from different economic sectors are examining and comparing. Earlier, Donnelly [1] indicated the application of Data Envelopment Analysis (DEA) to re-rank the organizations based on the EFQM approach. 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. Increasing of competitions intensity has motivated many top managers in manufacturing organizations evaluate their competitive strategies and management practices to improve the organizational performance. With a diminish workforce and needing to sustain performance, organizations are striving to define, implement and sustain Excellence Roadmap Practice.

It is argued that new management assessment tools, integrate strategy, and management practice; In addition, organizations yield a quality organization which improves and sustains better performance, continuously. Quality Management Award (QMA) has been used as a nationwide and global criterion during the last decade to compare improvement. QMA is one of three major Awards in Europe in the form of the EFQM Business Excellence Model originated from the Total Quality Management (TQM).

Following this global trend, Iranian industry leaders have introduced the EFQM practice to their supply chain in order to improve its supply base competitiveness during the last four years. The raised question is whether the EFQM model can be combined with mathematical model such as DEA in order to generate a new ranking method and develop or facilitate the benchmarking process. To answer this question, we, firstly refer to the EFQM basic model and DEA method and then make a mathematical model based on the combination of the EFQM conceptual model and DEA mathematical model. Finally, by using the collected data from EFQM assessment in Iranian automotive industry, we run the model and draw a Road Map to help executive managers identify benchmark companies.

2. Literature Review

The literature review is divided into two sections. We explain a summary of the EFQM Excellence Model in the first section and then concentrate on DEA method and its application in formulation and modeling problems.

2.1. The EFQM Excellence Model

The main purpose of the EQA was recognizing the organizational excellence in European companies since 1991. Westlund [2] 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.

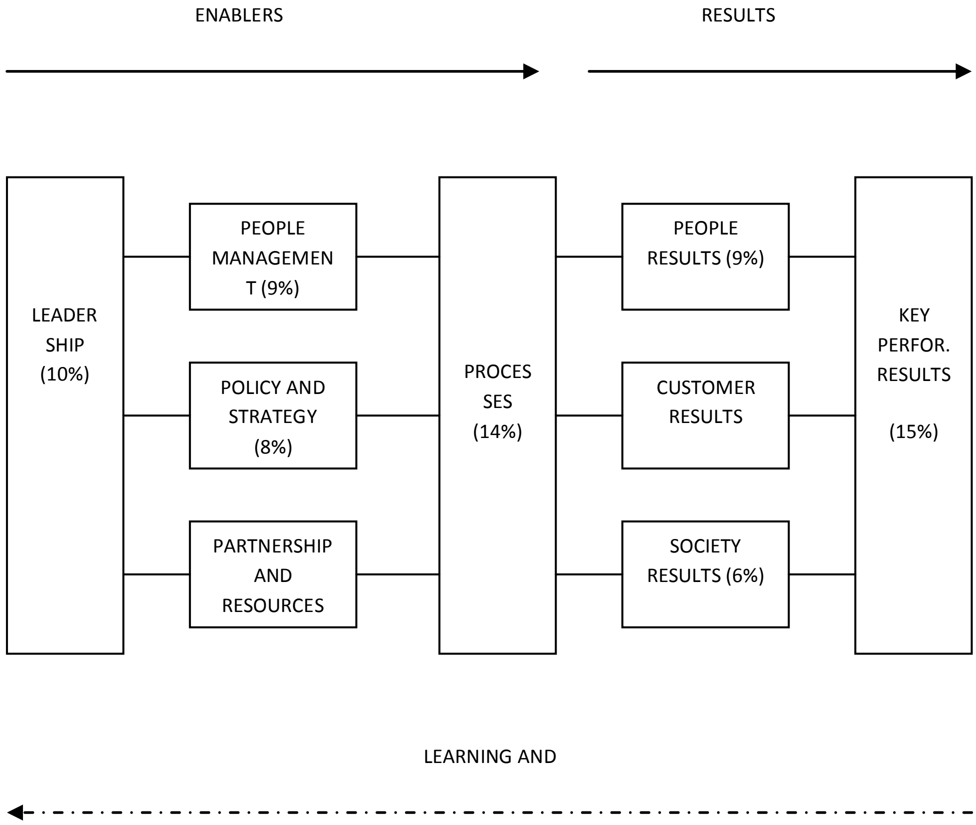

Figure 1. The EFQM Excellence Model, *Source: EFQM (1999).*

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 *et al.*, [3] 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 [4] 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., [5]* 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. Ghobadian and Woo [6] argued that the EFQM Excellence Model can be considered as a guide to introduce the TQM activities because the model combines the principles or fundamental concepts of TQM in clear and available language.

2.1.1. The EFQM Practice in IRAN

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.

2.2. Data Envelopment Analysis

Zhu [7] mention that 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. 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.

Charnes, Cooper, and Rhodes [8] 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 [9] 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* DMUs to be evaluated which each one consumes varying amounts of *m* different inputs to produce *s* different outputs. Specifically, DMU_j consumes amount x_{ij} of input *i* and produces amount y_{rj} of output *r*. Firstly, they introduce the "ratio-form" of DEA in which the ratio of outputs to inputs is used to measure the relative efficiency of the $DMU_j = DMU_0$ to be evaluated relative to the ratios of all of the $j = 1,2,\ldots,n$ DMU_j. In mathematical programming parlance, this ratio, which is to be maximized, forms the objective function for the particular DMU being evaluated, so that symbolically:

$$\max h_0(u,v) = \sum_r u_r y_{r0} / \sum_i v_i x_{i0}$$

A set of normalizing constraints (one for each DMU) reflects the condition that the virtual output to virtual input ratio of every DMU, including $DMU_j = DMU_0$, must be less than or equal to unity. The mathematical programming problem may thus be stated as:

$$\max h_0(u,v) = \sum_r u_r y_{r0} / \sum_i v_i x_{i0}$$

$$\text{Subject to } \sum_r u_r y_{rj} / \sum_i v_i x_{ij} \le 1 \; for j = 1,2,\ldots,n$$

$$u_r, v_i \ge 0 \text{ for all i and r}$$

A fully rigorous development would replace $u_r, v_i \ge 0$ with $\frac{u_r}{\sum_{i=1}^{m} v_i x_{i0}}, \frac{u_r}{\sum_{i=1}^{m} v_i x_{i0}} \ge \varepsilon > 0$ where ε is a non-Archimedean element smaller than any positive real number. See Arnold *et al.*, [10]. This condition guarantees that solutions will be positive in these variables. The above ratio form yields an infinite number of solutions; if (u^*, v^*) is optimal, then $(\alpha u^*, \alpha v^*)$ is also optimal for $\alpha > 0$. However, the transformation developed by Charnes and Cooper (1962) for linear fractional programming selects a representative solution [i.e., the solution (u,v) for which $\sum_{i=1}^{m} v_i x_{i0} = 1$] and yields the equivalent linear programming problem in which the change of variables from (u,v) to (μ,v) is a result of the Charnes-Cooper transformation :

(LP $_0$***)***

$$\max z = \sum_{r=1}^{s} \mu_r y_{r0}$$

Subject to

$$\sum \mu_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0$$

$$\sum_{i=1}^{m} v_i x_{i0} = 1$$

$$\mu_r, v_i \ge 0$$

For which the LP dual problem is :

(DLP $_0$***)***

$$\theta^* = \min \theta$$

Subject to

$$\sum_{j=1}^{n} x_{ij} \lambda_j \le \theta x_{i0}, i = 1,2,\ldots,m;$$

$$\sum_{j=1}^{n} y_{rj} \lambda_j \ge y_{r0}, r = 1,2,\ldots,s;$$

$$\lambda_j \ge 0, j = 1,2,\ldots,n.$$

The last model, is sometimes referred to as the "Farrell model" because it is the one used in Farrell (1957).

3. DEA and the EFQM Model of Business Excellence

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.

4. Problem Setting and Methodology

Each year, Iranian companies in automotive industry assess their affiliated companies by using the EFQM Excellence Model called "Iranian Excellence Award" (IEA). The main purposes of this Award are:

- Development of excellence culture among the Group Companies.
- To share the knowledge and experiences and to institutionalize the benchmarking culture among the companies.
- To emphasize on self-assessment in order to identify strengths and areas for improvements.
- To align between the goals and strategies.
- Using of a standard model to assess companies.
- To define improvement projects and trace the progress

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?

Schmidt and Zink [11] argued that the majority of the academic literature on self-assessment has concentrated on the main Quality/Excellence award models and comparison of their criteria, and the relationship between award winners and business results. Another work that has done by Ritchie and Dale [12] has concentrated on the self-assessment process with respect to issues such as deciding the assessment approach, the management of the process, the resource required, and selecting performance measurements. 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 Saipa Group strategic managers to goal setting for each criteria of EFQM business model. One of the main problems after conducting each assessment is how the companies can benchmark the best practices in nine criteria and which companies should be selected as benchmark. In the following we explain the modeling process. 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 Holding company Assessment Teams.

Table 1. Percentage Score for each criteria in Automotive's Group

Company No.	Leadership	Strategy	Human Resources	Resources	Processes	Customer Re.	Human Re.	Society Re.	Key Per. Re.
1	40.2	38.1	49.4	48.2	41	30.3	47.11	25.2	40
2	23	13.8	28.0	29.0	15	21.25	12.5	11.3	32.5
3	24	18.8	24.0	30.0	30	10	16.3	10.0	22.5
4	18	18.8	30.0	24.0	50	25	32.5	11.8	22.5
5	26.3	22.4	32.9	32.8	34.0	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	14.0	15.0	24	15	6.2	5.0	25
8	30	36.3	31.0	33.0	32	15	16	8.8	30
9	23	17.5	22.0	21.0	29	10	15	10.0	15
10	19	16.5	16.5	21.0	24	20	15	8.3	24
11	30	23.0	29.8	33.5	38	29.4	32	14.7	34.7
12	25	20.0	25.0	28.0	29	21.25	16	17.5	30
13	16	22.5	17.0	18.9	19	13.5	10	10.0	10.8
14	16	8.8	14.0	18.0	20	10	29	7.5	10
15	11	10.0	16.0	19.0	18	15	15	15.0	15
16	21	17.5	27.0	28.0	32	11.25	26	13.8	27.5
17	20	18.8	15.0	17.0	21	15	11	7.5	27.5
18	21	21.3	30.0	23.3	30	28.5	30	20.0	30
19	22	23.8	27.0	30.0	25	23.5	27	5.0	25
20	14	11.3	14.0	16.0	23	15	25	10.0	17.5
21	27	26.3	29.0	28.0	31	16.25	21	17.5	37.5
22	15	15.0	20.0	15.0	20	20	15	5.0	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	20.0	17	5.7	5	8.7	10
26	13	10.0	17.8	13.3	19	10	10	15.0	10
27	25	20.0	25.6	20.0	30	5	6	5.0	10
28	20	20.0	26.0	33.0	24	20	5	10.0	30
29	13.8	12.0	14.0	16.2	21	9.75	10	5.5	16.5
30	11.6	14.0	11.6	19.6	12	7	7	5.0	9
31	17	17.5	23.3	25.0	20	3.75	0	0.0	15
32	18	16.3	24.0	20.0	24	20	24	12.5	20
33	15	10.0	5.0	10.0	25	10	5	5.0	5
34	22	21.3	30.0	22.0	26	17.5	20	10.0	22.5
35	17	12.5	14.0	17.0	21	11.25	10	6.3	13.33
36	10	10.0	12.0	12.0	15	10	10	10.0	15
37	16	15.0	20.0	20.0	16	12.5	21	7.5	25
38	32.8	37.5	31.5	34.3	41	30	31	20.4	34.2
39	30	25.0	20.0	20.0	20	15	20	5.0	20
40	14.2	18.3	18.4	15.2	20	7	8	7.0	19.5
41	22	20.0	25.0	29.0	24	16.25	16	6.3	22.5
42	26	22.9	24.0	24.7	38	25.4	20	24.2	31.7
43	17	12.5	17.0	19.0	21	10	10	6.3	13.5
44	16	18.8	34.0	21.0	30	7.5	16	3.8	20
45	7.8	5.0	8.8	10.4	21	5	5	1.0	10
46	5	6.3	16.7	5.6	11	2.5	6	0.0	3.3

4.1. The Mathematical Modeling (DEA Model)

We designed a one-year EFQM assessment program for about forty six companies. The companies taken part in our analysis are from different business sectors but almost in automotive supply chain. The selected assessment teams for the process consist of fifteen 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. 2.

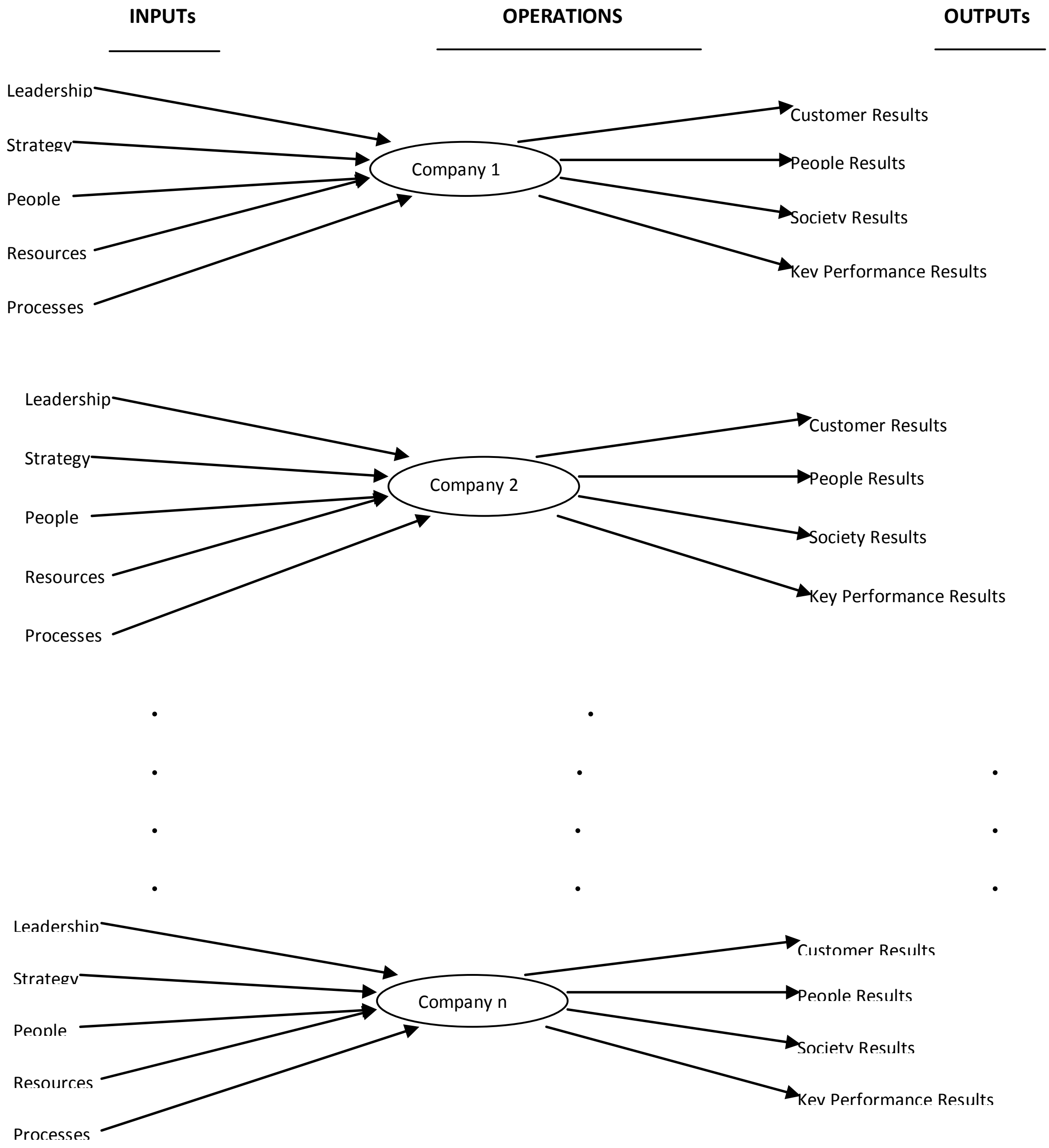

Figure 2. The EFQM Conceptual Model Based On DEA Approach.

4.1.1. Indices, Parameters and Variables

Indices:

i = 1,2,…,5 so that 1=leadership, 2=strategy, 3= people, 4= resources, 5= processes

r= 1,2,3,4 so that 1=customer results, 2=people results, 3=society results, 4= key performance results

j= 1,2,3,…,46 so that j refer to companies name

Parameters:

y_{rj} :score of results criteria r for companies j (r = 1,2,3,4) , (j = 1,2,3,…,46)

x_{ij} : score of enablers criteria i for companies j (i = 1,2,3,4,5) , (j = 1,2,3,…,46)

Variables:

u_r :weighted aggregate of the results score r (r = 1,2,3,4)

v_i : weighted aggregate of the enablers score i (i = 1,2,3,4,5)

$$Maxh_0 = \sum_{r=1}^{4} y_{r0} u_r$$

s.t. $$\sum_{i=1}^{5} x_{i0} v_i = 1$$

$$\sum_{r=1}^{4} y_{rj} u_r - \sum_{i=1}^{5} x_{ij} v_i \leq 0 \qquad (j = 1,2,3,\ldots,43)$$

$$u_r , v_i \geq \varepsilon, \forall i, j, r$$

The dual problem of (LP_0) is expressed with a real variable θ and a non-negative vector $\lambda = (\lambda_1,..., \lambda_n)^T$ of variables as follows (Envelopment form):

$$(\text{DLP}_0) \quad \underset{\theta,\lambda}{Min} \quad \theta$$

s.t :

$$\sum_{j=1}^{46} x_{ij}\lambda_j - \theta x_{i0} \le 0, i = 1,2,3,4,5$$

$$\sum y_{rj}\lambda_j \ge y_{rj}, r = 1,2,3,4$$

$$\lambda_j \ge 0, j = 1,\ldots,46$$

5. Solving the Model and Analyzing the Solutions

We used LINDO software to solve the two models (LP and Envelopment forms). The used inputs in the models are reversed because the greater enablers score, the higher the company EFQM total score. 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. 26 with the EFQM score of 128 has gained the 40th position but the 29th in the new ranking.

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

Company No.	EFQM score	EFQM rank	DEA score	DEA rank
1	394	1	128%	1
38	331	2	117%	2
4	271.6	5	100%	3
42	272	4	92%	4
11	307	3	91%	5
21	261	8	73%	6
18	269	7	70%	7
8	256	9	69%	8

5	271.3	6	63%	9
23	236	12	59%	10
12	242	10	56%	11
16	225	13	55%	12
28	218	14	49%	13
19	239	11	48%	14
2	216	15	47%	15
3	203	18	42%	16
32	203	19	39%	17
10	197	20	38.5%	18
7	177	25	38.3%	19
34	215	16	38%	20
39	195	21	37.7%	21
44	184	22	37.6%	22
17	170	23	35.4%	23
6	170	28	34.3%	24
41	204	17	33%	25
22	166	30	32.2%	26
20	167	29	30.7%	27
14	145	34	30.4%	28
9	178	24	29.1%	29
24	175	26	27.6%	30
26	128	40	27.1%	31
15	151	33	26.3%	32
13	152	32	26.1%	33
37	172	27	24.9%	34
40	142	35	24.5%	35
29	137	38	21.3%	36

33	107	43	19.8%	37
27	157	31	18.9%	38
35	140	37	18.8%	39
31	133	39	18.4%	40
43	141	36	17.4%	41
25	119	41	14.7%	42
36	118	42	14.6%	43
45	89	45	13.1%	44
30	106	44	10%	45
46	60	46	5%	46

The Wilcoxon Signed Ranks Test

The Wilcoxon Signed Ranks Test is a nonparametric alternative to the two sample t-test which is solely based on the order in which the observations from the two samples fall. We will use this technique to compare two populations. Suppose that we have samples of observations from each of two populations A (EFQM) and B (DEA) scores containing n_A and n_B observations, respectively. We wish to test the hypothesis that the distribution of X-measurement in the population A (EFQM score) is the same as in the population B which we will symbolically write as $\boldsymbol{H_0}$***: A=B (a).*** The departures from $\boldsymbol{H_0}$ that Wilcoxon test tries to detect are location shifts. If we expect to detect that the distribution of A is shifted to the right of distribution B as in Figure 3, we will write this as $\boldsymbol{H_1: A > B}$ ***(b).*** The other two possibilities are $\boldsymbol{H_1 : A < B}$, A is shifted to the left of B, and the two sided-alternative, which we will write as $\boldsymbol{H_1 : A \neq B}$, for situations in which we have no strong prior reason for expecting a shift in a particular direction.

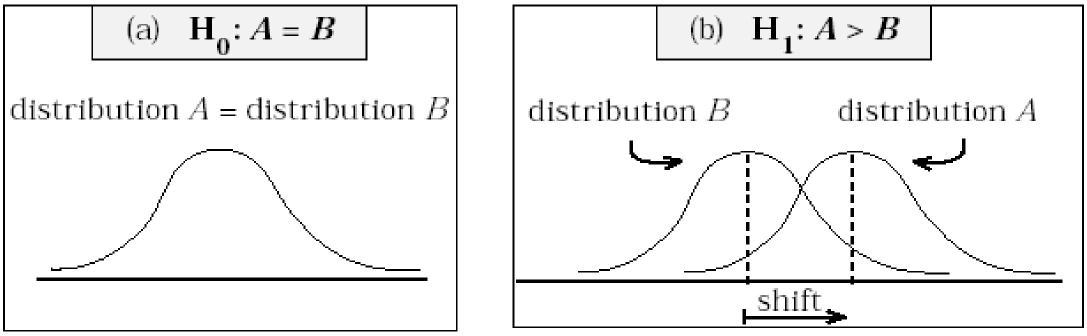

Figure 3-Illustrate of $\boldsymbol{H_0: A=B}$ versus $\boldsymbol{H_1: A > B}$

Thus we select to test the following hypothesis :

$$\begin{cases} H_0: A=B \\ H_1: A \neq B \end{cases}$$

Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
dea - efqm	Negative Ranks	2(a)	1.50	3.00
	Positive Ranks	44(b)	24.50	1078.00
	Ties	0(c)		
	Total	46		

a dea < efqm b dea > efqm c dea = efqm

Test Statistics(b)

	dea - efqm
Z	-5.872(a)
Asymp. Sig. (2-tailed)	.000

a Based on negative ranks.

b Wilcoxon Signed Ranks Test

Since test statistic is less than the critical value (level of significance is 0.05) then the H_0 hypothesis is rejected and the conclusion is that, as the evidence shows, at the 5% significance, the rank method does not have the same distribution. As we 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 Tables 3 and 4, we summarized the data for companies No.12 and 32. The data in "benchmark company" column is taken from the solution of the DEA model revealing that that the company No.12 the criterion of leadership must benchmark the company No.3 and for the criterion of policy and strategy must benchmark the company No.1 and 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.12.

Criteria	Target score	Real Achievement	Benchmark Company
Leadership	35	25	3
Policy & Strategy	32	20	1
Human Resources	45	25	2
Partnership & resources	37	28	4
Processes	40	29	1
Customer Results	50	21.25	3
Human Results	42	16	5
Society Results	25	17.5	2
Key Performance Results	43	30	1

Table 4. Data Related to Company No. 32.

Criteria	Target score	Real Achievement	Benchmark Company
Leadership	28	18	7
Policy & Strategy	30	16.3	9
Human Resources	35	24	12
Partnership & resources	32	20	6
Processes	38	24	16
Customer Results	40	20	4
Human Results	32	24	1
Society Results	18	12.5	3
Key Performance Results	36	20	9

In Fig. 3, we draw a Road Map to show how the outputs of the DEA model can help the companies to select the Benchmark Companies for each EFQM model criterion.

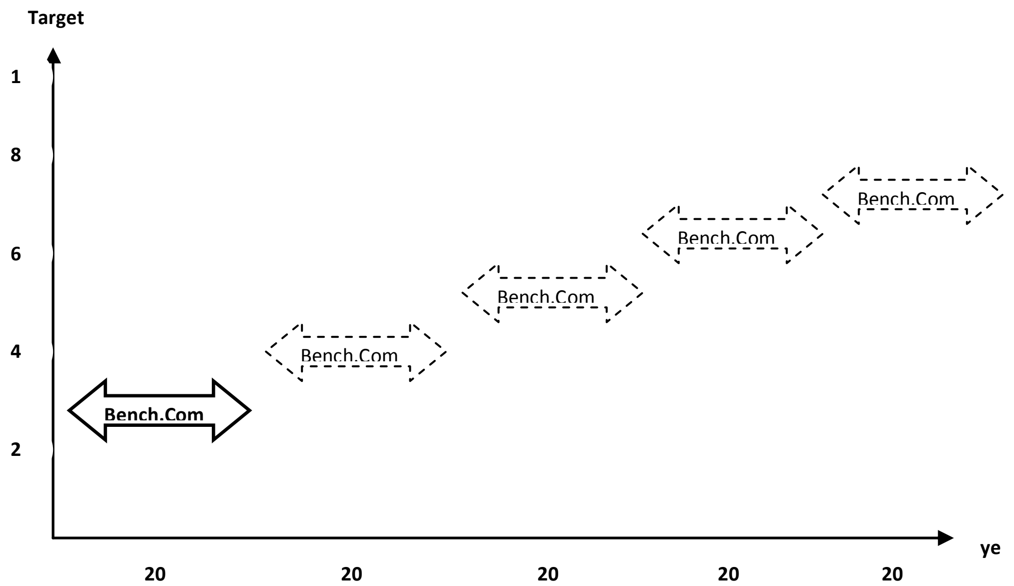

Figure 3. The Road Map for Leadership Criteria Target Score (Company No.32).

For example, the company No.32 must be the benchmark of the company No.7 for leadership criteria based on the data of 2007 and set target score for 2008. We, therefore, can draw this Road Map for other criteria of EFQM model for each company (e.g., the Benchmark Company 2009 will be determined by making a DEA model based on data collected in 2008, and so on).

6. Conclusions and Future Developments

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. We 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.

References

[1] Donnelly M., A radical scoring system for the European Foundation for Quality Management Business Excellence Model, Managerial Auditing Journal,15, 1-12, 2000.

[2] Westlund A. H., Measuring environmental impact on society in the EFQM system, Total Quality Management, 12(1), 125-35, 2001.

[3] Hillman G.P., Making self-assessment successful, The TQM Magazine, 6, 29-31, 1994.

[4] Porter L., and Tanner S., Assessing Business Excellence , Buttrworth-Heinemann, Oxford, 1996.

[5] Van der Wiele T., Dale B. And Williams R., Business improvement through quality management system, Management Decision, 38(1), 19-23, 2000.

[6] Ghobadian A., and Woo H. S., Characteristics, benefits and shortcomings of four major quality award, International Journal of Quality&Reliability Management, 13(2), 10-44, 1996.

[7] Zhu J., Quantitative Model for Performance Evaluation and Benchmarking: Data Envelopment Analysis with Spreadsheets and DEA Excel Solver, Kluwer Academic Publishers, Boston, 2002.

[8] Charnes A., Cooper, W.W. and Rhodes, E., Measuring the efficiency of decision making units , European Journal of Operation Research, 2, 429-44, 1978.

[9] Farrel M.J., The measurement of productive efficiency, Journal of Royal Statistical Society A, 120, 253-281, 1957.

[10] Arnold V., Bardhan I., Cooper W. W., and Gallegos A., Primal and Dual Optimality in Computer Codes Using Two-Stage Solution Procedures in DEA, Operations Research Methods, Models and Applications (Westpost, conn: Quorum Books), 1998.

[11] Schmidt A., and Zink K. J., Practice and implementatin of self-assessment, International Journal of Quality Science, 3, 5-17, 1998.

[12] Ritchie L., and Dale B.G., An analysis of the self-assessment practice using the business excellence model, Proceeding of the Institution of Mechanical Engineers, 204(B4), 593-602, 2000.