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Integration DEA into Six Sigma Methodology for Performance Evaluation of Yazd Science and Technology Park Technological Companies

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ABSTRACT

Evaluation of performance will enable an organization to reduce its dependence on government assistance due to efficient use of its resources and is one of the main problems in organizations. Customer's satisfaction is the most important goal of organization. In order to achieve that, organizations should perform effectively and efficiently. Integrating the DEA method into Six Sigma methodology used to enhance both the usefulness of Six Sigma and the effectiveness of DEA for assessing and improving efficiency. Adding quality tools to data envelopment analysis, the performance evaluation is done in a more effective manner. In order to improve organization performance, it's crucial to establish a constant and structured performance evaluation system through the organization. Due to the importance of performance evaluation and role of Science and Technology Park in country improvement, this paper is proposed to evaluate performance of 33 firms that are in Yazd Science and Technology Park in Iran, using integration Data Envelopment Analysis into Six Sigma methodology.

DMAIC circle helps researcher to take a comprehensive view on problems. In this paper, an inclusive approach is suggested in order to evaluate performance, combining DMAIC circle of six sigma and DEA.

Results of solving the output-oriented BCC model of DEA show that among 33 Technological firms in Yazd Science and Technology Park 17 companies are inefficient and 16 companies are efficient. The results of the sensitivity analysis show that by eliminating inputs Total assets, R&D expenditure and Capital and output number of licenses and number of contracts the efficiency scores have a greater impact on performance than the other criteria and performance of firms are reduced by the eliminating these criteria.

KEYWORDS: Performance Evaluation, DEA-Six Sigma, Yazd Science and Technology Park.

INTRODUCTION

Performance is one of the fundamental concepts of management, since most of managerial tasks are formed on the basis of that, to put differently, the successfulness of each organization is closely depended on their activities. In fact, performance covers all organizational requirements for achieving their defined objectives. So based on what has been explained above, the performances of each and every organization must be unique [1]. Most scholars define performance as the degree of achievement towards the set goal [2].

Evaluating the performance of organizations is a process through which we can evaluate the organizations based on their goals and mission and measure their success rate in achieving those goals or their deviation rate from them [3]. The performance evaluation plays a more and more important role in the modern enterprise management, and the method of evaluation system on enterprise performance is always an important question in the theory and practice [4]. The evaluating systems are very important mechanisms of control over the main policies of the organizations and give the managers very important and vital information about the level of compatibility and appropriateness of the branches with the given programs [3].

The high performance is the goal that an organization pursues. A rational and scientific method of performance evaluation, not only can carry out effective measurement to the past organization's performance, but also it helps to offer decision support to improve and optimize the performance for the future [5].

Performance evaluation can make the enterprise to recognize their advantages and disadvantages and find that there is unreasonable phenomenon, so as to further improve their management level [4]. Therefore, Performance evaluation will enable an organization to reduce its dependence on government assistance due to efficient use of its resources [6].

The performance evaluation is quite subjective, since it relies on the individual judgment of the managers who have different, various and multi-factor assessment methods of a system's performance [7]. Data envelopments analysis is one of the accepted methods for evaluating the performance of the organizations. This method is used to

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evaluate and compare the relative efficiency of decision making units like schools, hospitals, universities, banks, etc, which have several similar inputs and outcomes [8].

According to role of evaluation in organizations and the importance of science and technology parks in developing technology and economic growth in countries, this study evaluated the performance of 33 technological companies in Yazd Science and Technology Park in Iran applies integration Data Envelopment Analysis into Six Sigma methodology.

1-1- Performance Evaluation

Performance is a broad term because it depends upon how the organization defines it. For some organizations, performance refers to profitability, for some it means reach, for others it may be translated to customer service and satisfaction and yet, for others it can be defined as reputation and credibility. Any organization strives hard to improve its performance. This helps the organization to achieve its goals and objectives. The ability to improve performance lies in the ability to measure it [6].

The performance evaluation is a systematic review process carried out to help an organization reach a certain goal. Making performance evaluation part of the management and control system helps the organization to effectively manage its resources and measure its performance relevant to its goals [9].

Performance evaluation is for achieving the entire target. It bases on the quantification standard made in advance or using subjective judgment to assess the result of daily operation; meanwhile, performance evaluation also possesses the function of amending responding policies and unifying the target of individuals and organizations [10].

2-1- Science and Technology parks

Science parks are sources of entrepreneurship, talent and economic competitiveness for our nation and are key elements of the infrastructure, supporting the growth of today's global knowledge economy. They enhance the development, transfer and commercialization of technology [11].

One of the objectives in establishing the science park in most countries is to provide an infrastructure of technical, logistic and administrative support that a young firm is necessary in the process of struggling to gain a foothold in a competitive market [12].

Different criteria are used in order to evaluate the companies' performance in Yazd Science and Technology Park. They are shown in Table 1.

Table 1 Effective Criteria in performance Evaluation of companies in the Science and Technology Park

Criteria	Reference
Total assets	[13, 14, 15]
R&D Expenditures	[13, 16, 12, 15, 17, 18, 19, 20, 21]
Total number of employees	[13, 16, 17, 20, 22]
Number of patents	[16, 13, 11, 17, 18, 19, 21, 23]
Annual Sales	[16, 15, 19, 21]
Sales revenue	[13, 24]
Export volume	[13, 15, 20, 22]
Capital	[11, 25]
Current costs	[26, 27]
Number of licenses	[27]

Nosratabadi, et al., (2011) proposed a fuzzy expert system to evaluate the science and technology parks. Present a system which is able to compare this high number of science parks, with many criteria, is one of the findings of this paper [11].

Lu, et al., (2010) utilizes an empirical study to provide valuable managerial insights when measuring the impact of R&D activities and performance representation in the Taiwanese technological industry. This study develops a two-stage sequential technique for incorporating environmental effects into a method for evaluating R&D performance based data envelopment analysis (DEA) and ordinary least squares (OLS) regression with panel data to obtain an efficiency measurement. The study data comprised 194 technological firms analyzed from a multi-source database. The inputs and outputs in DEA is Total Assets, R&D expenditure, total number of employers, number of R&D, number of patents, export volume, return of investment and sales revenue [13].

Bigliardi, et al., (2006) have provided a sound and theory-grounded methodological framework to science parks performance measurement and some practical suggestions useful for the design and the implementation of a Science Park's (SPs) performance evaluation. Based on the analysis of four Italian case studies, the empirical findings partly lend support to previous research output and partly add new elements of discussion to the debate. More specifically, major results are that the evaluation criteria should be aligned with science park (a) actual mission, (b) major stakeholders commitment, (c) economic regional conditions, (d) legal forms, (e) nature of the scientific competence base available within research centers and (f) SP's life-cycle stage [23].

Sun & Lin, (2009) have analyzed efficiency and productivity growth of six high-tech industries in Hsinchu Science Park in Taiwan for period 2000-2006. In This paper DEA was applied to analyze the relative performance. In order to find out the long-term effectiveness in productivity, the window analysis is adapted to seek the most recommended set of industries for Hsinchu Science Taiwan by measuring the performance changes over time. Inputs and outputs are considered in this study include R&D expenditures, number of employees, working capital, number of patents and annual sales [16].

Jain, et al., (2011) presents a data envelopment analysis (DEA) based approach for performance measurement and target setting of manufacturing systems. The approach is applied to two different manufacturing environments. The performance peer groups identified DEA utilized to set performance targets and to guide performance improvement efforts. The DEA scores are checked against past process modifications that led to identified performance changes [28].

Kiakojoori, et al., (2011) evaluate the performance of each branch of the Azad Islamic University (IAU) in Mazandaran province, determining the role model and reference branches to define the inefficient branches by applying envelopment analysis and ranking the efficient branches of AIU in Mazandaran province by applying Anderson Peterson method [3].

2- MATERIAL AND METHODS

2-1- Data Envelopment Analysis

DEA is a non-parametric technique used to measure the efficiency of DMUs. It considers that each DMU is engaged in a transformation process, where by using some inputs (resources) it is trying to produce some outputs (goods or services). DEA uses all the data available to construct a best practice empirical frontier, to which each inefficient DMU is compared [29].

The most frequently used DEA models are CCR and BCC with constant and variable returns to scale, respectively. According to the objective of a model, the DEA models can be categorized into two types: input-oriented model and output-oriented model. The input-oriented model intends to minimize inputs with given outputs, whereas the output-oriented model does to maximize outputs with given inputs [30].

The linear program of the basic DEA model is as follows, which can be solved relatively easily and a complete DEA solves n linear programs, one for each DMU.

$$\begin{aligned} \max \quad & \sum_{r=1}^{s} u_r\, y_{rj} \\ s.t. \quad & \sum_{i=1}^{m} \upsilon_i\, x_{i0} = 1 \\ & \sum_{r=1}^{s} u_r\, y_{rj} - \sum_{i=1}^{m} \upsilon_i\, x_{ij} \le 0 \qquad j = 1,2,\dots,n \\ & \upsilon_i \ge 0 \qquad i = 1,2,\dots,m \\ & u_r \ge 0 \qquad r = 1,2,\dots,s \qquad (1) \end{aligned}$$

Model (1), often referred to as the CCR model, assumes that the production function exhibits constant returns-to-scale. The BCC model adds an additional constant variable, W, in order to permit variable returns-to-scale:

$$\begin{aligned} \max \quad & \sum_{r=1}^{s} u_r\, y_{rj} + W \\ s.t. \quad & \sum_{i=1}^{m} \upsilon_i\, x_{i0} = 1 \\ & \sum_{r=1}^{s} u_r\, y_{rj} - \sum_{i=1}^{m} \upsilon_i\, x_{ij} + W \le 0 \qquad j = 1,2,\dots,n \\ & \upsilon_i \ge 0 \qquad i = 1,2,\dots,m \\ & u_r \ge 0 \qquad r = 1,2,\dots,s \qquad (2) \end{aligned}$$

Here, x_{ij} is the amount of ith input, y_{rj} is the amount of rth output, v_i is the weight given to the ith input, u_r is the weight given to the rth output, and k is the DMU being measured [30].

It should be noted that the results of the CCR input-minimized or output-maximized formulations are the same, which is not the case in the BCC model. Thus, in the output-oriented BCC model, the formulation maximizes the outputs given the inputs and vice versa [31].

2-2- Integration of DEA into Six Sigma

One of the advantages of the Six Sigma methodology over other process improvement programs is that the use of data analysis tools in Six Sigma projects enables practitioners to accurately identify process hindering problems and demonstrate the improvement using objective data. Most of the existing tools in Six Sigma methodology are quality management tools and statistical methods, which is quite natural because Six Sigma was originated from statistical concepts for quality improvement. Typical quality management tools are process mapping, cause-and-effect diagrams, Pareto charts, quality function deployment, and failure mode and effect analysis. Examples of the statistical methods include statistical process control, design of experiments, analysis of variance, hypothesis testing, regression analysis and so forth. These quality management and statistical tools are effective in finding and eliminating causes of defects in business processes by focusing on the inputs, outputs, and/or the relationship between inputs and outputs. However, these methods for eliminating defects are usually insufficient in handling other types of process-improvement problems, such as workforce scheduling, resource planning and operations management. Among many operations research techniques, the DEA method is well suited to identify the efficient and inefficient individuals that can further facilitate resource planning or performance assessment. The integration of DEA into the Six Sigma framework will result in a synergistic effect that outperforms what can be achieved by the individual application of DEA. To our best knowledge, DEA has not been included into the Six Sigma toolbox that many Six Sigma practitioners are familiar with. The relationship of DEA with other tools needs to be specified in the DMAIC phases [32].

3-2- METHODOLOGY

In this study 33 Technological companies were selected as DMUs of Data Envelopment Analysis in Yazd province Science and Technology Park. To analyze data, DEA-Solver software has been used. The implementation procedure of DEA in each phase of DMAIC is illustrated in table2. Six Sigma tools that can facilitate the implementation of DEA are listed in last column.

Table 2 DEA in the DMAIC framework

DMAIC phases	Procedure for implementing DEA	Other tools facilitating DEA
Define	Identify the decision-making units (DMUs) Define inputs and outputs involved in assessing DMUs' efficiency	Fuzzy Delphi
Measure	Develop data collection plan Collect inputs and outputs data Verify data accuracy and reliability	Data collection plan
Analysis	Apply appropriate DEA models to obtain efficiency scores for DMUs Analyze relatively efficient DMUs Analyze relatively inefficient DMUs	Summary statistics
Improve	Provide reference sets for inefficient units Set performance targets for all units	Planning to improve the performance of inefficient firms
Control	Provide methods to ensure proper functioning in the future Providing methods for Performance Evaluation of companies	Box Plot

4- RESULTS

The implementation procedure of DEA in DMAIC circle has been proposed in following sections.

1-4- Define Phase

In the Define phase, the multiple inputs and outputs of DMUs are identified. In this study, The DMUs are Technological companies in Yazd Science and Technology Park. By reviewing researches that were conducted in firm's performance evaluation in Science and Technology Park, Effective criteria were identified.

In this research Fuzzy Delphi was used in define phase to determine the most important criteria in evaluating the performance of Technological firms in Yazd Science and Technology Park and identifying inputs and outputs in DEA.

In Delphi Method the experts are provided with an initial questionnaire and are requested to give their opinion separately and anonymously about the variables in question. The initial questionnaires are returned to a coordinator, who analyses the responses. Based on the statistical findings, a second questionnaire is interspersed to the participants, who are asked if they wish to revise their earlier estimates. This process is followed again and again until the outcome converges to a reasonable solution from decision makers, view point a pre-determined number of iterations is completed or stability in the results is obtained [33].

Experts expressed their agreement about effective criteria in performance evaluation of technological companies in Yazd Science and Technology Park with linguistic variable, such as low, medium and high. By defining the range linguistic variables, the experts will answer questions with the same mind. Linguistic variables are described as trapezoidal fuzzy numbers. Low (0,0,2,4), medium (3,4,6,7) and high (6,8,10,10) [34].

In this study After Experts were selected, the Delphi was repeated four rounds. In the first round, a list of effective Criteria in performance evaluation of Science and Technology Park was given to experts. Also, they were asked to express the criteria that were effective in performance evaluation of firms but not in list based on their opinion or their experience. Finally, two criteria were added which include total currency contracts and number of contracts. As regards the significance of view in property value, the answers of the initial round were collected and statistically analyzed according to Eq. (2)

$$A^{(i)} = \left(a_1^i, a_2^i, a_3^i, a_4^i\right), \quad i = 1, 2, 3, \ldots, n \qquad (1)$$

$$A_m = \left(a_{m1}^i, a_{m2}^i, a_{m3}^i, a_{m4}^i\right) = \left(\tfrac{1}{n}\sum a_1^{(i)}, \tfrac{1}{n}\sum a_2^{(i)}, \tfrac{1}{n}\sum a_3^{(i)}, \tfrac{1}{n}\sum a_4^{(i)}\right) \qquad (2)$$

At this stage, the experts were asked to amount the importance of criteria in performance evaluation Technological companies of Science and Technology Park in Yazd Province of Iran, as low, medium, and large. Then, for each expert the deviation between Average and her/his initial estimate (Ai) was computed following Eq. (3)

$$e = \left(a_{m1} - a_1^{(i)}, a_{m2} - a_2^{(i)}, a_{m3} - a_3^{(i)}, a_{m4} - a_4^{(i)}\right)$$

$$= \left(\tfrac{1}{n}\sum a_1^{(i)} - a_1^i, \tfrac{1}{n}\sum a_2^{(i)} - a_2^i, \tfrac{1}{n}\sum a_3^{(i)} - a_3^i, \tfrac{1}{n}\sum a_4^{(i)} - a_4^i\right) \qquad (3)$$

The distance between two fuzzy numbers was calculated by measuring the deviation between the average fuzzy evaluation data and the experts' evaluation data (Eq. 4). In this study, difference that was calculated is less than the threshold value of 0.2 set by this research and is thus acceptable for the group consensus [35].

$$S\left(A_{m2}, A_{m1}\right) = \left|\frac{1}{4}\left[\left(a_{m21} + a_{m22} + a_{m23} + a_{m24}\right) - \left(a_{m11} + a_{m12} + a_{m13} + a_{m14}\right)\right]\right| \qquad (4)$$

Finally 11 criteria selected that showed in table 3.

Table 3 Inputs and outputs for performance evaluation of Technological companies

Inputs	**Total assets, R&D Expenditures, Total number of employees, Capital, current costs**
Outputs	Number of patents, Export volume, Sales revenue, number of licenses, total currency contracts, number of contracts

2-4- Measure Phase

The Measure phase quantifies and benchmarks the process using actual collected data. The data collection process involves developing a collection plan, collecting data, and verifying data accuracy and reliability that are implemented in the Measure phase.

In this phase data collected in considering the input and output of the define phase and existing documents in each technological company in Yazd Science and Technology Park.

Table 4 shows information about the inputs and outputs of each Technological company in Yazd Science and Technology Park.

Table 4 Values of inputs and outputs of Technological firms of Yazd Science and Technology Park

DMU	**1**	**2**	**3**	**…**	**31**	**32**	**33**
Total assets (Million)	50	700	10	…	2500	500	100
R&D Expenditures (Million)	9.9	90	0	…	400	180	150
Total number of employees	6	5	4	…	8	3	4
current costs (Million)	10	13	25	…	80	25	30
Capital (Million)	10	500	1.5	…	100	30	10
Number of patents	9	2	0	…	3	0	0
Export volume (Million)	10	0	0	…	0	0	0
total currency contracts (Million)	9	4	750	…	2000	150	6000
number of contracts	10	3	0	…	2	2	2
number of licenses	10	180	5	…	10	10	15
Sales revenue (Million)	9	460	750	…	2000	250	6000

3-4- Analysis Phase

Data collected will be analyzed in the Analyze phase. For a DEA, the formulation and solution of the DEA model are primary outcomes of this phase. A set of efficient DMUs and a set of inefficient DMUs are concurrently identified in the DEA's solution. An appropriate DEA model should be selected depending on the nature of application.

By implementing the BCC model of DEA, the efficiency of each 33 companies (DMUs) are determined, based on the Variety returns-to-scale assumption and they ranked considering their efficiency. The results are shown in table 5.

Table5 Results of BCC model

DMU	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Efficiency Score	1	0.612	1	1	1	0.661	0.846	1	0.477	1	1
Ranking	1	23	1	1	1	21	20	1	27	1	1
DMU	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**
Efficiency Score	1	0.372	1	0.405	0.375	0.545	0.884	0.39	1	1	0.474
Ranking	1	32	1	29	31	24	19	30	1	1	28
DMU	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**
Efficiency Score	0.954	0.324	0.528	1	1	0.98	1	1	0.659	0.5	1
Ranking	18	33	25	1	1	17	1	1	22	26	1

The results show that among the 33 Technological companies in Yazd Science and Technology Park, 16 companies are efficient and 17 are inefficient.

Summary statistics were used in the Analyze phase. The Mean, minimum, maximum and the standard deviation for inputs, outputs and DEA scores listed in Table 6.

Table 6 Summary Statistics

		Mean	**STD.Dev**	**Min**	**Max**
Input	Total assets	1572.83	3278.48	10	15000
	R&D Expenditure	135.99	283.61	0	1500
	Total number of employees	10.87	11.03	2	40
	Capital	48.31	94.99	1	500
	Current Cost	113.87	241.8	6	1300
Output	Number of patents	0.84	1.6	0	6
	Export volume	307.57	1740.05	0	10000
	Sales revenue	4815.42	10949.43	0	60000
	total currency contracts	2486.30	3793.87	0	15000
	number of licenses	2.78	2.07	0	10
	number of contracts	86.75	224.17	0	1000
Efficiency Score		0.78	0.25	0.32	1

4-4- Improve

The Improve phase determines the best solution using optimization approaches. As a linear programming technique for optimization, DEA can naturally be incorporated into the Improve phase be planned for improving the performance of inefficient firms. Specifically, the results from the DEA can provide reference sets for inefficient DMUs and set performance targets for all DMUs. Considering the coefficients of the reference sets with combination efficient DMUs create a virtual DMU. By comparing the input and output of the virtual DMU inefficient units, optimal inputs and outputs are identified to inefficient units achieve efficiency.Table 7 presents actual and target values and reference set for DMUs, as well as the DEA score.

Table7 Compare the actual and target values to improve the performance of inefficiency Technological located in Yazd Science and Technology Park

DMU	Reference set		Inputs					Outputs					
			I1	I2	I3	I4	I5	O1	O2	O3	O4	O5	O6
2	21,12,5,1	Target	700	90	5	500	13	2	0	460	4	3	180
		Actual	581	96	4	12	13	5	95	739	654	5	281
6	1,8,26	Target	50	5	5	10	20	0	0	120	150	4	8
		Actual	519	20	10	10	49	4	5	642	642	6	20
7	1,12,21,26,33	Target	150	50	20	100	100	0	40	600	1000	4	40
		Actual	144	22	4	5	14	3	43	1420	1420	5	47
9	1,11,12,29,33	Target	120	150	5	200	50	0	0	600	1200	3	20
		Actual	120	59	5	9	19	5	5	2211	2211	6	42
13	11,12,27,29,30	Target	2500	30	11	10	1300	0	0	2250	3900	2	11
		Actual	641	30	11	7	80	0	0	7736	1044	5	34
15	1,3,33	Target	30	40	5	5	30	0	0	500	500	1	2
		Actual	30	21	4	4	22	3	2	1230	1230	2	7
16	29,1	Target	1500	240	5	12	30	1	0	50	100	3	2
		Actual	67	7	5	8	10	1	1	25	25	1	1
17	27,26,12,10,1	Target	435.504	8	12	5	60	1	0	720	720	3	16
		Actual	138	8	7	5	17	3	3	1317	1420	5	29
18	33,29,12,1	Target	500	100	4	30	15	0	0	2000	2500	2	50
		Actual	161	40	3	5	15	0	0	2826	2826	2	56
19	1,12,27,33	Target	200	100	7	50	40	0	0	1000	1000	3	20
		Actual	199	26	7	11	27	6	6	2566	2564	8	52
22	10,11,26	Target	50	10	3	1	15	0	0	400	400	1	9
		Actual	50	1	3	1	13	0	0	1239	1365	2	28
23	1,11,21,27,30,33	Target	1200	250	10	10	150	2	0	7000	7000	1	6
		Actual	1198	126	10	10	76	3	593	7315	1085	5	23
24	8,29,30	Target	800	0	6	180	42	0	0	650	650	1	0
		Actual	616	0	6	29	25	0	0	1997	1997	3	9
25	33,30,27,12,1	Target	250	60	15	30	50	1	0	2600	2600	4	10
		Actual	249	18	10	12	50	6	6	2563	2563	8	52
28	30,29	Target	700	0	40	10	160	0	0	8000	8000	1	3
		Actual	252	0	10	10	76	0	0	369	369	0	2
31	1,4,11,21,30	Target	2500	400	8	100	80	3	0	2000	2000	2	10
		Actual	470	49	8	10	39	7	227	2975	2975	8	15
32	1,26,29	Target	500	180	3	30	25	0	0	250	150	2	10
		Actual	69	2	3	3	11	1	1	1800	1800	3	15

In table 7 for example companies 1,5,12 and 21 are reference set for company 2. The coefficient of reference set is calculated by BCC output of DEA. It was clear the coefficient of reference set for Efficient DMUs is one.

Sensitivity analysis of inputs and outputs

Sensitivity analysis of inputs and outputs were used to determine the effective inputs and outputs of Technological companies. Thus, the output-oriented BCC model is run again, and each time it is removed from the input or output. Table 8 shows the results of sensitivity analysis.

Table8 the results of sensitivity analysis

DMU	1	2	3	4	5	6	7	8	9	10	11
Total assets	1	0.612	0.321	1	1	0.642	0.451	1	0.469	1	1
R&D Expenditure	1	0.612	1	1	1	0.5	0.846	0.402	0.477	1	1
Total number of employees	1	0.612	1	1	1	0.661	0.846	1	0.466	1	1
Capital	1	0.612	1	1	1	0.661	0.846	1	0.477	0.572	1
Current Cost	1	0.598	1	1	1	0.661	0.846	1	0.477	1	1
Number of patents	1	0.612	1	1	1	0.661	0.846	1	0.477	1	1
Export volume	1	0.612	1	1	1	0.661	0.57	1	0.477	1	1
Sales revenue	1	0.598	1	1	1	0.661	0.846	1	0.477	1	1
total currency contracts	1	0.612	1	1	1	0.661	0.809	1	0.423	1	1
number of licenses	1	0.57	1	1	1	0.215	0.768	0.105	0.34	0.455	1
number of contracts	1	0.458	1	1	0.756	0.661	0.602	1	0.463	1	1
DMU	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**
Total assets	1	0.372	1	0.17	0.375	0.545	0.884	0.366	1	1	0.466
R&D Expenditure	1	0.352	0.501	0.405	0.375	0.496	0.884	0.39	1	1	0.474
Total number of employees	1	0.332	1	0.405	0.3	0.545	0.884	0.373	1	1	0.461
Capital	1	0.372	1	0.405	0.375	0.36	0.884	0.39	1	1	0.302
Current Cost	1	0.372	1	0.405	0.375	0.545	0.608	0.39	1	1	0.474
Number of patents	1	0.372	1	0.405	0.375	0.545	0.884	0.39	1	1	0.474
Export volume	1	0.372	1	0.405	0.375	0.545	0.884	0.39	1	1	0.474
Sales revenue	1	0.372	1	0.405	0.375	0.543	0.884	0.38	1	1	0.474
total currency contracts	1	0.269	1	0.227	0.375	0.545	0.747	0.39	1	1	0.474
number of licenses	1	0.337	0.414	0.263	0.21	0.434	0.858	0.21	1	1	0.3
number of contracts	1	0.371	1	0.405	0.375	0.52	0.857	0.353	1	1	0.474
DMU	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**
Total assets	0.935	0.324	0.433	1	1	0.98	1	1	0.659	0.5	1
R&D Expenditure	0.954	0.157	0.528	1	1	0.764	1	1	0.659	0.5	1
Total number of employees	0.894	0.286	0.528	1	1	0.98	1	1	0.631	0.205	1
Capital	0.95	0.324	0.528	1	1	0.533	1	1	0.659	0.5	1
Current Cost	0.954	0.324	0.517	1	1	0.98	1	1	0.659	0.5	1
Number of patents	0.754	0.324	0.528	1	1	0.98	1	1	0.321	0.5	1
Export volume	0.954	0.324	0.528	1	1	0.98	1	1	0.659	0.5	1
Sales revenue	0.855	0.279	0.524	1	1	0.98	1	1	0.644	0.5	1
total currency contracts	0.907	0.324	0.528	1	1	0.98	1	1	0.528	0.5	1
number of licenses	0.954	0.132	0.44	1	1	0.98	1	1	0.659	0.071	1
number of contracts	0.954	0.324	0.518	1	1	0.98	1	1	0.659	0.5	1

The results of the sensitivity analysis relevant to the most important and least important inputs and outputs show that by eliminating inputs Total assets, R&D expenditure and Capital and output number of licenses and number of contracts the efficiency scores compromise with other inputs and outputs has the highest rate of decline. This shows the importance of these criteria in performance evaluating of Technological companies. But by eliminating inputs Total number of employees and Current Cost and outputs Export volume, the efficiency scores were increased compromise with other inputs and outputs. This shows the less importance of these criteria in performance evaluation of companies.

5-4- Control Phase

In the control phase, according to sensitivity analysis of data envelopment analysis, the criteria include Total assets, R&D expenditure and Capital and output number of licenses and number of contracts are important criteria. Box Plots were drawn, to evaluate status companies in these criteria. The results show that in Total assets and R&D expenditure more companies are located in remote areas. About total assets criteria, the median is the middle, so the assumption of symmetry is a powerful data distribution. Figure 1 show the box plot of total assets.

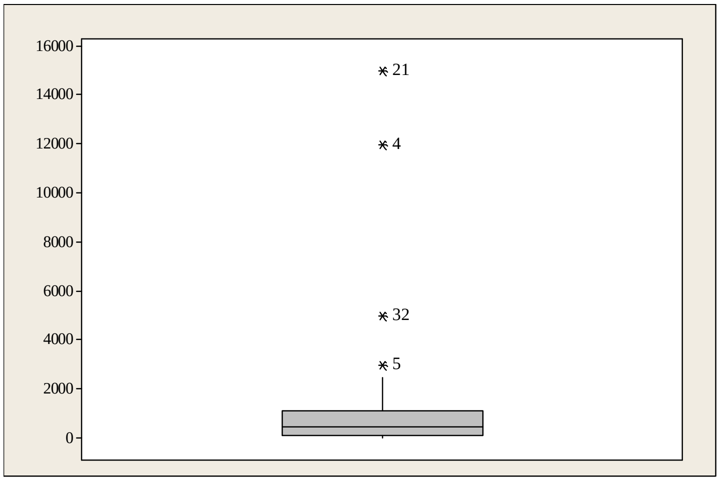

Fig.1. Box Plot of total assets

5- DISCUSSION AND CONCLUSION

Performance evaluation is the process of determining efficiency and productivity of the methods applied to achieve set objectives. Performance evaluation system can also be expressed as all indicators that measure productivity and efficiency activities in a company [36].

This paper has presented the implementation of DEA into each phase of the DMAIC process. 33 technological companies in Yazd Science and Technology Park in Iran are selected to implement proposed methodology.

Most research about performance evaluation used the basic model of data envelopment analysis and other techniques used in this field, such as balanced scorecard [11, 23, 27]. Also, research in the field of science and technology parks evaluated parks and incubators, does not evaluated the firms in Science and Technology parks. In comparison with other existing techniques for performance evaluation of organizations, data envelopment analysis is the most appropriate [37]. Integrating the DEA method into Six Sigma methodology used to enhance both the usefulness of Six Sigma and the effectiveness of DEA for assessing and improving efficiency. Adding quality tools to data envelopment analysis, the performance evaluation is done in a more effective manner. In this research, with survey of literature review and opinion from experts, the effective criteria in performance evaluation of Technological companies in Yazd Science and Technology Park were identified and for performance evaluation of them integrating DEA into the six sigma methodology was used.

Results of solving the output-oriented BCC model of DEA show that among 33 Technological firms in Yazd Science and Technology Park 17 companies are inefficient and 16 companies are efficient.

The results of the sensitivity analysis show that by eliminating inputs Total assets, R&D expenditure and Capital and output number of licenses and number of contracts the efficiency scores have a greater impact on performance than the other criteria and performance of firms are reduced by the eliminating these criteria. So, Technological companies in Yazd Science and Technology Park should be given more attention to these criteria.

In future research recommend evaluation of performance of the Science and Technology Parks which have used fuzzy approach. Also suggested integrating DEA was applied into six sigma methodology to evaluate six sigma projects in the field of performance evaluation.

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