

Developing Productivity Monitoring System in a governmental organization with multi-performance objectives: A case study in National Iranian Gas Company

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Abstract— As a goal of Iranian governmental vision in 2020, the total productivity share of all Iranian sectors must be reached to 31.3% of GDP (at least). All the efforts and infrastructure should be developed in order to meet this goal. For this purpose a research project has been defined in National Iranian Gas Company (NIGC) for productivity measurement of Technical Inspection departments and the BSC-DEA model has been developed in order to measure productivity using Productivity Monitoring System (Multi-Performance Objectives). The finding of this project (which is still under development) is presented in this paper. The MADM methods are applied to choose the proper KPIs of performance objectives. The BSC approach which is applied in this project provides a methodology to determine the KPIs .Developing productivity monitoring system using DEA method will be a useful tool for further steps of continues improvement. Application of this approach is illustrated by a case study in NIGC Technical Inspection department.

Keywords— *Productivity measurement, BSC, DEA, KPI, Performance Monitoring, Efficient, In Efficient, Continuous Improvement*

I. INTRODUCTION

According to the "Law of the Fourth Economic, Social and Cultural Islamic Republic of Iran" (upstream strategic documents) for increasing total productivity of governmental organizations and as a goal of Iranian vision in 2020, the total productivity share of all Iranian sectors must be reached to 31.3% of GDP (at least). Based on this aim, all the infrastructures should be developed in order to reach this goal [1].

By developing an optimal and efficient Performance Monitoring System using BSC-DEA method, the continues improvement toward the strategic goal will be performed correctly. Performance monitoring is the set of processes which is control the performance of organization/personnel over a specific time by comparing the current status with favorite condition based on the assignable indexes (driven attributes) using a scientific approach (such as BSC-DEA) and developing the model for further usage.

Nowadays in such a dynamic competitive working environment of our organizations, road-mapping is faced the uncertainty issues; Availability of right Data at the right time for decision makers is vital; Most of the critical information for decision making, at the best case are unclear and at worst case are inaccessible. Thus, in the most cases, decision makers' opinions and subjective judgments must be replaced by the missing information and the qualitative criteria must be estimated which is often very difficult to estimate in the absence of quantitative measurements. The use of qualitative indices, such as awareness of the market and customer satisfaction level is considered as very important Key Performance Indicators (KPIs). [2]

A popular performance measurement technique (which was introduced by Norton and Kaplan in 1992) is the Balanced Scorecard (BSC) method (including qualitative criteria) that uses performance combination of different aspects from customer point of view, internal business process, financial, and technological perspectives. This model is named as the recent managerial innovation for performance measurement; In 2004, this technique is used for establishing alignment between the organization's human resources (HRs), strategies, information and organizational capital, and translate the organization strategies into the routine activities. [3]

The main issue of using BSC methods is determination of the base-line and identifying the best-practice (as a pattern) for measuring organizational performance according to this standard. Without this base-line (standard), measurement is impossible [4]; meanwhile the determination of the standards is difficult and often misleading. To solve this issue, a hybrid model of Balanced Scorecard (BSC), and the data envelopment analysis (DEA) was proposed in this project.

A nonparametric DEA technique in the evaluation method is used to evaluate exchanges between alternative performance metrics. DEA-based models are widely used in various surveys, studies and research and case-studies, including the assessment of the effectiveness of educational institutions [5], evaluating the effectiveness of Iranian provincial gas distribution companies [6], performance measurement of research and development departments in NIGC and in sub-companies [7], Financial condition of the organizations [8].

The objective of this technique is to achieve the same relative efficiency of decision-making, which has multiple similar inputs /outputs [9].

Although the number of DEA-based model increases rapidly during recent years, the basement of them are the same which the founders introduced the limited of original ones. For example the Charnes, Cooper & Rohdes (CCR) with Constant Return to Scale [10] and the other model Banker, Charnes & Cooper (BCC) with Varying Return to Scale [11].

Since the DEA techniques are based on comparative analysis, DMUs are evaluated against each other. Thus the hybrid model (BSC-DEA) can solve the problem of using BSC model which is determining the base-line. [4]

The purpose of this paper is to present a new model of DEA with an emphasis on indices Balanced Scorecard. The main advantage of this model is the balance between BSC aspects, some of the previous surveys in using DEA in combination of BSC, after solving DEA model some of the weights of BSC perspectives are calculated to zero or weights variance is to high in some cases, thus the weights of perspective are not equal.

II. THE BALANCED SCORECARD (BSC)

In early 1990, Nolan Norton institute has performed a research by the title of "Future organization performance measurement"[12, 13]. David Norton as the executive director of the institute, acted as the leader of this research and Robert Kaplan worked as an academic consultant [14].

The result, according to Kaplan and Norton stated, is the set of criteria that creates a comprehensive and accurate outlook of the business to the managers. They observed that the companies will not be able to create and develop their competitive advantage only by maintaining their tangible assets [15]. Balanced scorecard measures organizational performance in four perspectives: financial, customer, internal processes and learning and growth that are associated with the four tasks of accounting and finance, marketing, value chain and human resources [16].

Kaplan and Norton believe that managers in today's organizations for managing complex business and uncertain working environment for the best performance must look out for balanced perspectives from several angles[17, 18]:

- How do customers see us?
- In order to satisfy shareholders and customers in which processes we must be excellence?
- Can we continually improve our goals and create values?
- How should be represented in front of stakeholders?

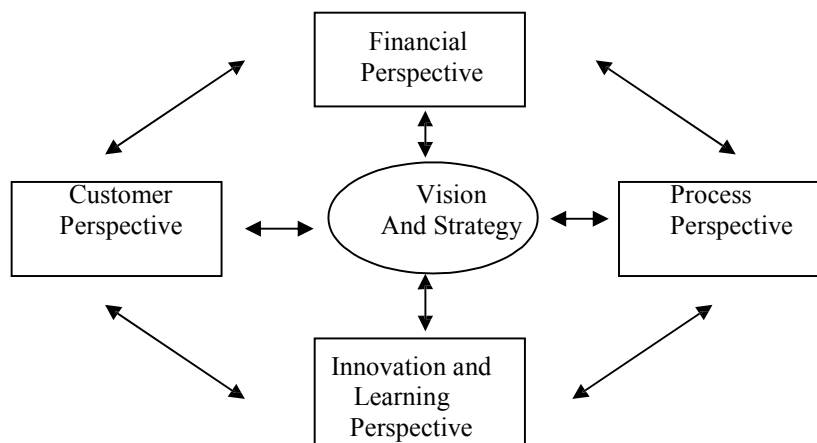


Fig. 1. The Balanced Scorecard strategy and perspective causality [19]

Balanced Scorecard by showing the level of organizational performance helps managers to improve the performance of their respective sectors. The BSC approach provides the opportunity for diagnosis organization. In this regard, all the efforts must be done to define and apply appropriate criteria to measure organizational performance. Kaplan and Norton believe that

balanced scorecard should be used as learning system, exchange information and develop communication, not as a control system [20]. Thus the BSC may use as continuous improvement tool [12, 21, 22].

III. THE DATA ENVELOPMENT ANALYSIS (DEA)

Productivity concept has a long history of management science [24]. The productivity shows how good an organization uses its own resources to produce, in comparison with the best practice at some time and condition [25]. DEA is used as planning techniques that are widely used to evaluate the efficiency of similar units that have multiple similar inputs / outputs [26].

The DEA is a nonparametric technique based on mathematical programming which is evaluate the productivity of decision making units (DMUs) and there is no need to determine the characteristics of parametric (such as distribution and production function) to gain productivity ratings as a significant advantage of its usage [27].

From one perspective DEA models could be classified into two categories: DEA input-oriented model and input-oriented model. The object of DEA input -oriented model is to present the improving way by decreasing the inputs and output-oriented model goal is to design the improvement method by increasing the outputs. Suppose we have n number of DMUs and m number of inputs s number of outputs, the relative productivity of each DMUs is calculated individually from below equation (Primary DEA model) [12]:

$$\begin{aligned} \text{Max } Z_0 &= \frac{\sum_{r=1}^s u_r y_{r0}}{\sum_{i=1}^m v_i x_{i0}} & (1) \\ \text{s.t. } \frac{\sum_{r=1}^s u_r y_{rj}}{\sum_{i=1}^m v_i x_{ij}} &\leq 1, j=1,2,\dots,n \\ u_r, v_i &\geq 0 \end{aligned}$$

In this model, every single performance rating is under review by dividing the sum of the weighted outputs to the sum of the weighted inputs obtained the rating is less than or equal to one. If the score is equal to a one, The DMU is efficient and if it is less than one, it is considered as inefficient. Despite all the advantages that can be expressed technique for DEA, one of the weaknesses of this technique is the lack of enough resolution in the cases where the number of DMUs are reduced or the number of inputs and outputs increased; whereas the new hybrid approach can solve this issue.

IV. THE HYBRID DATA ENVELOPMENT ANALYSIS – BALANCED SCORECARD (DEA-BSC)

As previously mentioned, combination of DEA and BSC can solve one of the major obstacles, which is the need of standards and baseline; because the DEA is based on relative analysis. DEA from a family of models with different assumptions about the input-output relationships which are under consideration by the DMUs. [4]

Rickards (2003) believes that applying the DEA performance analysis of BSC results could be a good solution for implementing BSC in the organization. Calculated performance boundary by DEA could be applied for measuring DMUs performance. Rickards stated that DEA can help to decide how BSC indices objectively are determined. [23]

In the hybrid DEA-BSC technique, the BSC is used as a tool for designing performance evaluation indexes and the DEA is performed as a tool for evaluating the organizational performance.

The main advantages of using this model are as below:

- To ensure that, there are a good relationship between the goals, objectives and strategies of one side to the Key Performance Indicators (KPIs) from other side;
- There is a good balance of KPIs from various aspects of the organization;
- Assessing the organization in comparative environment upon its experienced during previous years or similar organizations;
- Introducing the path to improve and developing criteria based on scientific performance evaluation results;
- Determination of the indexes objectives based on the improvement path.

A. Analysis of the conceptual model

As a conventional approach in evaluation of the organizations performance and institutions and generally DMUs, it is widely common to use the ratio as a means of measuring performance. Rated performance of a single DMU in general, is derived as a weighted sum of outputs divided by the weighted sum of inputs.

In simple systems which include very limited inputs/outputs, such this ratio and compares for measuring the performance of units could be done easily; however, in real conditions there are several inputs/outputs affecting performance and are used for organization performance analysis. Thus the use of DEA techniques seems reasonable.

B. Recognition of BSC criteria

After reviewing previous studies and surveys of experts, indicators of the BSC for the technical inspection departments of the National Iranian Gas Sub-Companies were identified and confirmed as below.

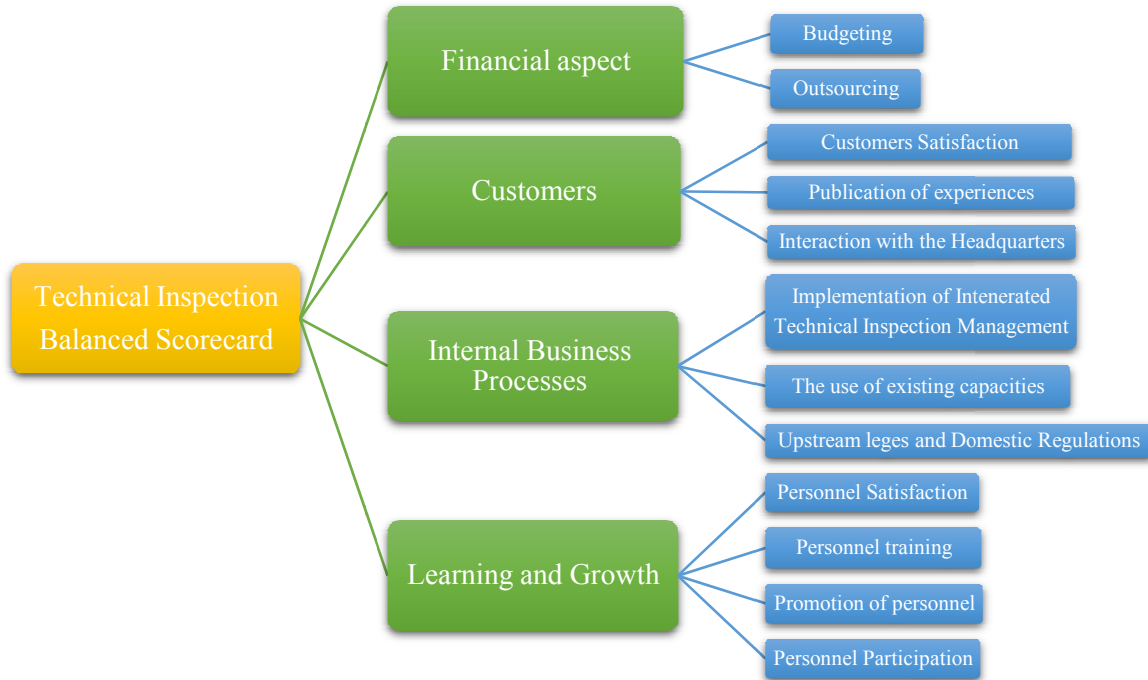


Fig. 2. Technical Inspection Departments BSC criteria

C. Definition of decision making units (DMUs)

A single decision-making unit is an organizational unit or a separate organization which is directed by a manager or responsible person if this unit has a systematic process meanwhile a set of production factors/services to be applied to gain a product/services.

The similar DMUs are the units that convert the inputs to output, the same type of tasks are performed; the inputs and outputs are from the same kind and have the same goals and aspirations.

In this research the DMUs are the Technical Inspection Departments of NIGC sub companies including 8 gas processing plants, 10+1 gas Transmission district and gas Transmission main Company and gas Engineering and Development Company and gas Storage Company.

D. Determination of model inputs/outputs

After holding multiple meeting with different level of managers in mentioned companies and discussing about the issue from several perspectives, as well as review of previous research on DEA-BSC hybrid models, the inputs and outputs were determined; the inputs are HRs, assets and capitals and services and the outputs were all the criteria the BSC which is shown in Figure 2. As well in Figure 3 shows an overall view of the input and output of purposed model.

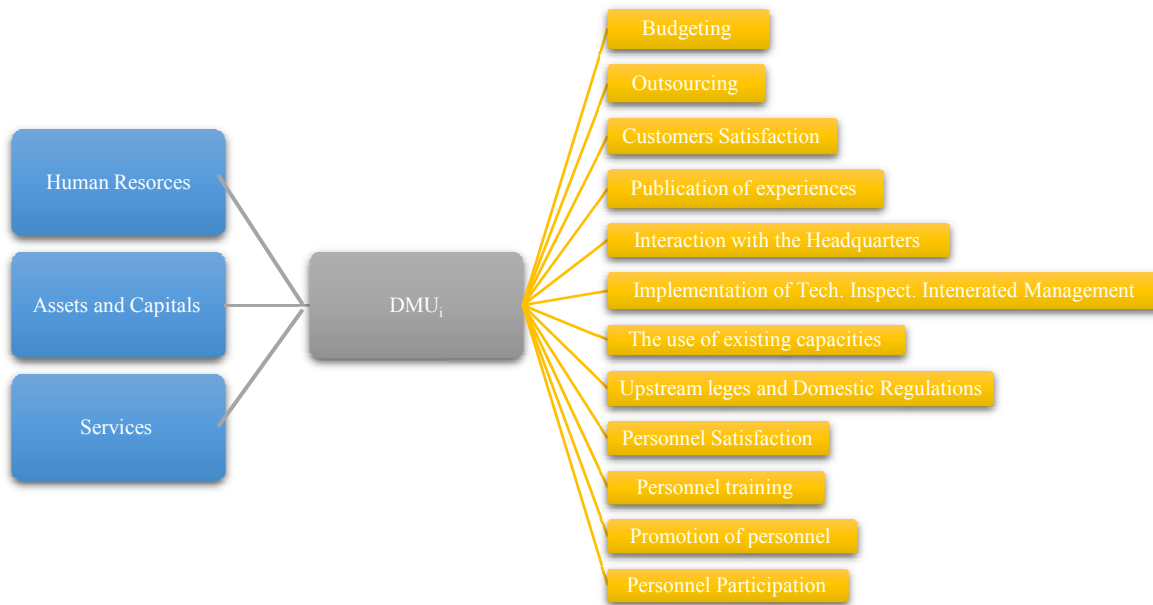


Fig. 3. Overall view of the input and output of DEA-BSC model

E. Feature of DEA Model used in research

The choice of model feature depends on the degree of control that management can apply on the inputs/outputs of single DMU. In this study, the DEA model with output-oriented performance evaluation model on the technical inspection departments is used because it seems to management, can exert more control over the inputs and outputs; on the other hand, the aim of this research offer guidelines to managers to improve and balance the proposed indicators in the balanced scorecard, all of which are part of the output-oriented model.

F. Design of a balanced Hybrid Model (DEA-BSC)

The model used in this study is a developed model from the basic DEA model. In this model, two sets of balancing restrictions is added to classic DEA are added, which guarantee to keep the balance in the proposed dimensions of the BSC perspectives. These limits act in such a way that, firstly, the weight given to each aspect of the BSC between a lower and upper limit (which is determined by experts) And secondly, the total weight of all four perspectives are equal to one.

$$L_k \leq \frac{\sum_{r \in O_k} u_r y_{r0}}{\sum_r u_r y_{r0}} \leq U_k ; \forall_k \quad (2)$$

$$\sum_{k=1}^K \frac{\sum_{r \in O_k} u_r y_{rj}}{\sum_r u_r y_{rj}} = 1 ; \forall_j$$

s.t. $\sum_{k=1}^K L_k \leq 1 ; \sum_{k=1}^K U_k \geq 1 ; L_k \leq U_k \forall_k ; 0 \leq U_k \forall_k$

Where O_k are the main BSC perspectives; L_k are the lower weighted limit and U_k are the upper weighted limit of each BSC aspects

Finally, after a survey of experts, upper and lower limits of each of the dimensions of the BSC for these departments were obtained as it shows in TABLE I.

TABLE I. OBTAINED UPPER AND LOWER LIMITS OF BSC ASPECTS

BSC Aspects	Lower Limit (L_k)	Upper Limit (U_k)
Financial aspect	0.2073	0.3715
Customers and shareholders	0.2120	0.3222
Internal business processes	0.1532	0.3459
Learning and growth	0.1769	0.2998
Total	0.7494	1.3394

After that the purposed model is developed by AIMMS 3 (the Advanced Integrated Multidimensional Modeling System)

As the next step the computer aided performance monitoring system is planned and programmed by the software engineers as the web-based (for remote users in mentioned companies) including several forms of data entering (inputs) and management dash-boards, monthly reports and etc. as outputs.

Furthermore it is planned to run this system as the 1st time in selected companies/districts and gather the feedbacks from DMUS, management, users, personnel and rectify the bugs and problems.

Finally implementation the monitoring system in all purposed companies and do the ranking processes in all DMUs.

The overall steps of this research are shown in figure 4:

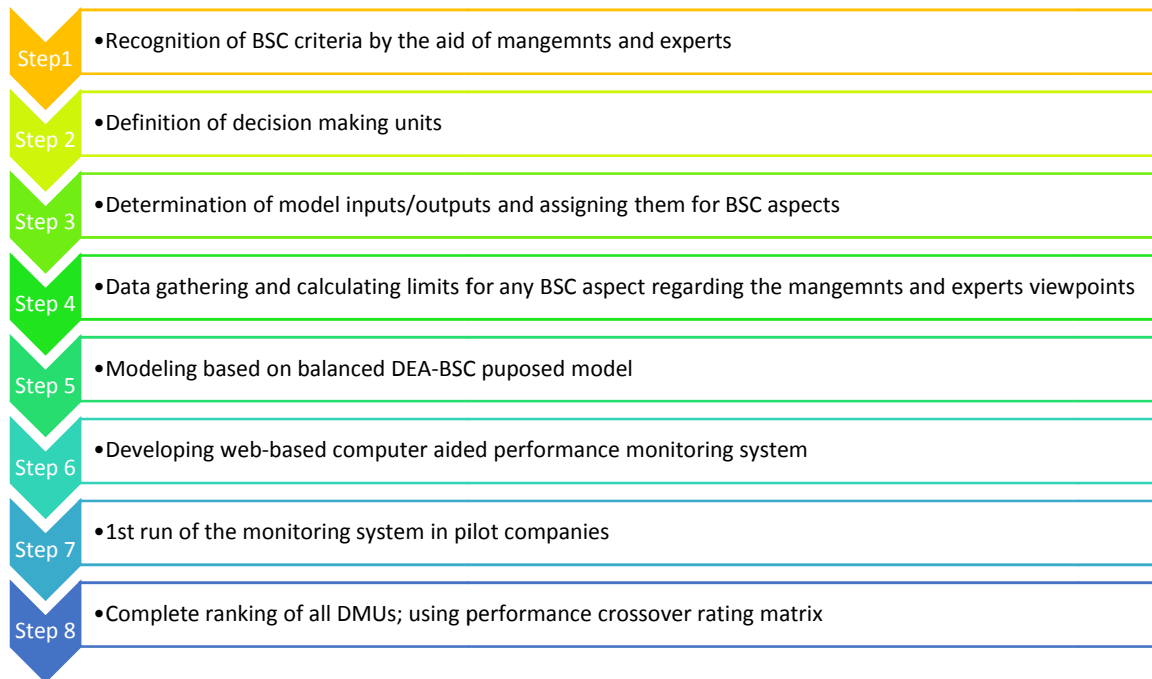


Fig. 4. Purposed research steps

V. RESULTS AND FINDINGS

Although it is too soon for analysis the results of implementation of performance monitoring system in NIGC technical inspection departments, the management team are satisfy with the processes of designing model and choosing indices based on BSC in a hybrid DEA-BSC.

VI. CONCLUSION

The main advantages of the proposed model were:

- Balancing the BSC perspective,
- Linearity,
- High resolution and flexibility within the parameters of the model

This model implemented by considering all the criteria and their weights and the Key Performance Indicators (KPI) and high level of reliability, according to the experts viewpoint, which confirmed the validity of the model.

The assessment in the comparison with similar organizations, to determine the path to improve performance evaluation criteria based on scientific results, the achievement of strategic objectives, expected outputs and achieve optimal arrangement budget to balance, were the attribute of this research. The results of this study, identifying appropriate indicators to rank technical inspection departments in 20 sub-companies of NIGC. The other result of this research is the development the basic DEA models and customizing it for performance evaluation in our company. Based on the results of the research, the following suggestions to improve the organizational performance of technical inspection is presented:

- Based on the results of DEA models, in order to increase the performance in lower rankings (inefficient DMUs); the optimal unit could be introduced to CEOs and executives managers in order to plan for improvement (Benchmarking from the Best-Practice), for this purpose the performance level in any criteria could be defined exactly; and such these DMUs could increase their ranks in the next evaluation of performance, if their inputs/outputs touch the identified level.

- As a matter of planning, it is suggested that make shore that there is a good relation between objectives and strategies from one side and the identified KPIs from another side and also to ensure there is a balance between the KPIs and all functional aspects of the organization and not only financial aspect, Previous scurvies show that there were several companies which were efficient by the unbalanced criteria but in the DEA-BSC model could not maintain their effectiveness and became in efficient in the balanced model; in addition the balanced approach could help organization improve the performance and effectiveness also in long-term causes gaining the competitive advantage.

VII. SUGGESTION FOR FURTHER RESEARCHES

- System designing for reviewing defined criteria based on feed-backs during identified period of time
- Development of DEA-based models to increase HR effectiveness in governmental organization

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The template will number citations consecutively within brackets [1]. The sentence punctuation follows the bracket [2]. Refer simply to the reference number, as in [3]—do not use “Ref. [3]” or “reference [3]” except at the beginning of a sentence: “Reference [3] was the first ...”

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BIOGRAPHY

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