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Project performance evaluation with earned value management approach using the integrated method of data envelopment analysis and Malmquist productivity index (Case study: bridge construction projects of Shiraz Municipality)

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ABSTRACT

Given the importance of performance evaluation in Iran's economic growth and development, project performance measurement is of great importance for developing countries such as Iran, which is on the way of the initial stages of its industrialization process. The present study is aimed to evaluate the project performance with earned value management approach using the integrated method of data envelopment analysis and Malmquist's productivity index. The research method is applied in terms of purpose and descriptive-analytical in nature. The statistical population of the current study includes 4 bridge construction projects of Shiraz municipality in 2022 and sampling method was not used in this research. The present study calculates efficiency with data envelopment analysis and Malmquist's productivity index. For this purpose, the concepts of efficiency and the introduction of data envelopment analysis technique is presented as one of the methods of efficiency measurement and also the concepts of Malmquist's productivity index are also discussed. By computing efficiency using Deap software, it was found that three projects are efficient and one project tis inefficient. By calculating Malmquist's productivity index, it was indicated that project D has the highest productivity and project B has the lowest productivity.

Keywords: performance evaluation, data envelopment analysis, Malmquist productivity index

Introduction

The performance evaluation system of project is a system that evaluates and measures the work and it also refers to the obtained result with an index scale that can carefully evaluates the given quality and quantity of the organization. The performance evaluation of implemented projects enables determining the strengths and weaknesses according to the nature of the project [1]. Project performance evaluation in traditional methods is based on three fields: time, cost and quality. In new studies, the project management triangle alone cannot fulfill all the needs of the project manager in the field of complete control of project performance [2]. The indices in the three mentioned areas are the main elements for evaluating the total success of the project and are easily measurable and interdependent during the project, but they cannot cover the performance of all aspects of the project and are not fully flexible in performance evaluation [3]. Project managers consider measuring their organization's performance as inevitable to achieve their strategic goals [4]. For the progress and improvement of the company, managers attempt to evaluate the challenges created by this complexity and environmental changes with strategic evaluation and control [5]. The increasing complexity of organizations and their increasing competition verifies the necessity of using performance evaluation models. The complex competition and rapid developments have caused performance evaluation systems to change and improve in accordance with these complexities, because in today's

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progressive and technological world, the intensified market competition is observed in the organizations' relations. In a performance evaluation process, the efficiency and effectiveness of operations are quantified. Performance evaluation can be useful for the manager in controlling the current situation, presenting the future direction and modeling other organizations. These matters are the communication goals of the organization [6]. Also, one of the results of a successful evaluation is the design of a reward system and encouraging employees to learn, and as a result, attaining the organization's motivational goals. In a competitive and complex environment, the presence of an integrated and comprehensive system for performance evaluation is necessary. Because the systems that focus only on the organization's finances will have no position in the intensified competition. In order to outperform its competitors, the organization should consider all aspects, such as financial and non-financial, and plan for them [7]. There is an increasing interest in the issue of project success both in the academic community and in the management community. This concept includes key success factors and the method of measuring criteria refers to key performance indicators. Although the success analysis can be different based on the type of sector and project class, there is no consensus on the method of measuring the success of projects with key performance indicators. Project success should be regarded as the main tool for organizational and social prosperity. Therefore, the definition of success can be different according to different contexts. The factors of a project choose a more subjective form depending on what someone wants to view in a project [8]. Success defines project in accordance to fulfill the expectations of various stakeholders, including the owner, planners and engineers, builders or executers of the participants [9, 10].

One of the most effective project time and cost control systems is earned value management. Earned value management enables managers to accurately calculate time, cost, and quality deviations from schedule at any time [11]. Earned value management is a definite project monitoring and control technique that has been widely used in many industries, including construction [12]. Earned value management is a comprehensive performance measurement system that combines cost and schedule parameters into a single methodology to provide relative awareness to project managers and clients in assessing project cost, timing, and technical performance of project. Earned value management is a tool that organizations use to report and control performance of project objectively. Earned value management, which is used as a performance management system, contributes to the success of the organization [13].

Review of literature

Research basics

Gradually, projects become more complex and also move towards contracts, in which the end user is not involved with the interface between parts of a system, but only deals with a single supplier in supplying the whole system. Important challenges are created when "human perception" is used in the measurement process. The concept of "measurement" is critical. In the first half of the 20th century, "measurement" was of great importance that the English association for the advancement of science set up a committee of physicists and psychologists on the possibility of presenting quantitative estimates of human perception, and a committee on the impossibility of matching the views of physicists and psychologists regarding the shared understanding of measurement [14]. Measuring non-physical features, such as project progress, leads to the similarity with more forms of evaluation, including estimation and judgment. This requires confirming a subjective component of measurement, at least as it relates to the inevitable existence of measurement judgment [20], which results in measurement turning into a decision-making activity. This has extensive implications for project management, but the effect of human dynamics is not widely considered in project management methods [15].

Performance management is a permanent process that involves determining goals and repeatedly evaluating development toward attaining those goals. Also, it includes activities that indicate organizational goals are consistently met in effectively and efficiently [16]. The criterion of performance is aspects of output that are applied for evaluation purposes [17]. Measuring the present and past performance of an organization is an important debate, because the inability of the organization to transform strategies into actions is due to the weakness of the performance measurement system, which affects the management of the organization in collecting correct information to monitor the process in attaining its strategic goals [18]. The appropriate selection of performance measurement tool for an organization is not only process-oriented, but also meet two requirements for the system [19]. Effective performance evaluation tools can be divided into two groups, which are performance measurement characteristics and performance measurement design. The performance measurement attribute defines the organizational approach required to measure performance. The design of performance measurement shows the elements that should be taken into consideration when selecting the suitable tool. Furthermore, selection is made by focusing on the system requirements (what is going to be measured, and the measurement requirements (how to measure it) [20]. Earned value management is one of the highly applied and famous methodologies for project control and monitoring as it integrates scope, cost, time, and schedule into a single framework. This program allows

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project managers to measure and verify project progress and detect deviations from the project planning phase so that early corrective measurements can be taken. The purpose of project performance evaluation is to measure and evaluate the actual progress of projects with some techniques such as earned value management in order to complete the project timely and based on the planned budget. At the beginning of the project, an initial estimate of the planned duration and cost is presented [21].

Research background

The project efficiency evaluation is one of the most important research debates around the world. As it was mentioned, performance evaluation has a considerable effect on the progress of the organization. In this section, it is attempted to discuss some researches on the evaluation of the efficiency of the projects conducted in Iran and abroad.

Local studies

1- In a study "evaluating the performance of construction projects based on identified and clustered implementation barriers using the data envelopment analysis method with a case study in the executive affairs of the Housing Foundation of Chaharmahal and Bakhtiari province", Fatahi and Shirvieh (2019) found that the longer the projects are from the center of the province and the more adverse weather conditions and social problems, the more barriers there will be in the execution process [1].

2- Gholamian (2016) performed a study "project operational performance evaluation by combining the earned value management approach and the learning curve theory". He stated that the integrated forecasting method for evaluating the performance of knowledge-based projects has the lowest mean percentage of performance forecasting error in the studied research. Therefore, it can be concluded that the proposed models provide more convincing results compared to the conventional methods of performance evaluation [22].

3-In a study, "TOPSIS coherent approach to evaluate top management faculties of universities in Tehran province", Mehrgan and Dehghan Nayyeri (2008) used TOPSIS compensatory model to summarize the results of evaluation from the different aspects of balanced score card model [23].

4- In 2017, Jahan Tighi performed study "a model to choose a project with limited resources using data envelopment analysis. In fact, evaluation and selection were combined in the new model by placing a data envelopment analysis model inside a binary linear programming problem. Thus, choosing a set of projects based on their performance in comparison with others groups should be examined [24].

5- In a study, " using the PROMET method to evaluate and rank contractors of construction projects with a case study of mass housing builders in Mehr housing of Shahr Jadid, Hashtgerd", Nasrullahi (2014) Collected the required data using other different methods such as reviewing documents or visiting projects . He used quantitative and qualitative indicators at the same time, determining the weight of the indicators differently, and applied sensitivity analysis on the results, and used other multi-attribute decision making models for ranking [25].

6- In 2013, Vafadar Asghari et al. conducted a study "the assessment of the relative efficiency of Mehr housing projects using the data envelopment analysis with a case study of cities with more than 25,000 inhabitants in Sistan and Baluchistan province. It was found that the execution of Mehr housing projects was efficient in Chabahar, Khash, Zahedan, and Kanarak and was ineffective in Iranshahr, Zabul, and Saravan [26].

International studies

1- In a study done by Villalba Romero and Liyanage (2016)" Evaluating success in PPP road projects in Europe: a comparison of performance measurement approaches", the results show how projects with public and private challenges may be evaluated to extract conclusions about the success/failure of a project from a global view, indicating the contexts and elements that need to be considered during this process [8].

2- Ming-Lang Tseng (2010) conducted a study "Implementation and performance evaluation using the fuzzy network balanced scorecard", evaluated university performance that provides four main aspects: student acquisition, service quality comparison, service cycle processing time, and faculty/employee satisfaction that are highly required for the aspects of internal operations , learning and growth. Therefore, management should improve the quality of internal services to provide effective internal processing time and should present faculty and staff satisfaction surveys from the students' view [27].

3- In a study, "Cross-efficiency evaluation in data envelopment analysis based on prospect theory ",Hui Liu et al., (2018) found that the proposed approach can be effectively used to various evaluation problems such as financial management and investment selection. However, we do not consider the regret of decisions when using the PCE model to evaluation problems. Despite our interest in introducing regret theory in the cross-efficiency model, we decide to investigate this topic for future studies and it may lead to complex calculations and our model cannot be applied in an extended framework and identify efficient and inefficient universities [28].

4- Holod (2011) conducted a study "Resolving the deposit dilemma: A new DEA bank efficiency model", and analyzed the effect of the amount of deposits on the overall efficiency of the bank depends on the efficiency in both stages. Although the modified version of the model considers deposits as an intermediate product rather than an input or output, it does not enable us to obtain separate efficiency estimates for each stage. Our original model requires separation of inputs to gain more

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insight into the bank's performance at each stage. Such a separation can be an interesting topic for future studies [29].

5- Maritza Torres Samuela et al., (2020) in a study "Performance of education and research in Latin American countries through data envelopment analysis" found some divergences regarding the export efficiency and the positioning in innovation. Regarding the efficiency of the countries, Argentina, Ecuador, Colombia, Honduras and Guatemala were 100% efficient in the three analyzes conducted in each cluster [30].

6- Nguyen and Thi Bich Pham (2020) in a study "The cost efficiency of Vietnamese banks – the difference between DEA and SFA" showed that the cost efficiency obtained under the stochastic frontier analysis models is much more consistent compared to the data envelopment analysis models. However, efficiency scores based on data envelopment analysis are more similar in terms of ranking order and stability over time. The inconsistency in the efficiency features of the two different methods reminds policy makers and bank managers to compare and select a suitable frontier criterion for each stage and special economic conditions [31].

Research Methodology

The present study is developmental-applied in terms of purpose, and it is qualitative and quantitative in terms of data nature. Also, it is longitudinal and quasi-longitudinal in terms of data collection, and descriptive and correlational from the aspects of research problem. In this study, by determining the input and output values of the projects with data envelopment analysis and the Malmquist index, the productivity of each specific project is calculated. In the first step, a decision-making team including experts is created. These people were selected due to their accessibility, opinion and also their knowledge about the projects of the studied organization. Then, the selected data coverage analysis model, the Malmquist index, and the input and output of the projects are determined based on the opinion of the decision-making team. In the following, by data collection of the first and second stages and using the selected models, the relative efficiency of the projects and their productivity are determined. For applied study, active bridge construction projects in Shiraz municipality have been chosen. The active construction projects of bridge construction in Shiraz municipality include 4 projects, which have been selected as the statistical population of the present study. This paper didn't use the sampling method and all the statistical population including active bridge construction projects in 2022 were examined.

Data envelopment analysis technique

Data envelopment analysis models are divided into two groups: input-oriented and output-oriented. In the input-oriented models, the inputs decrease by keeping the outputs constant, and in the output-oriented models, by keeping the inputs constant, the outputs are increased. Return to scale is also a concept indicating the relationship between changes in inputs and outputs. This ratio of changes can be constant or variable (ascending or descending) . In the data envelopment analysis, if the analysis is on the outputs and the efficiency is regarded to be a constant scale, the model used is the CCR model in the nature of the output as expressed in Equation 1:

$$FOR\ DMU_o: min \sum_{i=1}^{m} v_i x_{io}$$

$$\overset{s.t}{\sum_{r=1}^{s}} u_r y_{ro} = 1 \qquad r = 1. \ldots . S$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \geq 0 \qquad j = 1 . \ldots . n \quad i = 1. \ldots . m$$

$$u_r . v_j \geq \varepsilon$$

In the input-oriented data envelopment analysis (DEA), we attempt to achieve technical inefficiency ratio that should be minimized in the inputs so that the unit is placed at the efficiency frontier without changing the amount of outputs. But, in the output-oriented type, we are looking for a ratio that the outputs should be maximized so that the unit reaches the efficiency frontier without changing the amount of inputs. The following efficiency determination model is called the input-oriented CCR model and is expressed as Equation 2:

$$Max \quad \sum_{j=1}^{m} u_r y_{ro}$$

$$s.t. \quad \sum_{j=1}^{m} v_i x_{i0} = 1$$

$$\sum_{j=1}^{m} u_r y_{rj} - \sum_{j=1}^{m} v_i x_{ij} \leq 0$$

$$v_i \geq 0 \quad . \quad u_r \geq 0. \ j = 1. \ldots . n$$

The difference between the BCC model and the CCR model is variable returns to scale. In the constant returns to scale, an increase in input leads to an increase in output proportionally. But in variable returns, the increase in output is more or less than the ratio of increase in input. The input-oriented BCC model is as shown in Equation 3:

$$Min \quad \emptyset$$

$$s.t. \quad \sum_{j=1}^{n} x_j \lambda_j \leq \theta x_o .$$

$$\sum_{j=1}^{n} y_j \lambda_j \geq y_o$$

$$\sum_{j=1}^{n} \lambda_j = 1.$$

$$\lambda_j \geq 0. \ j = 1. \ldots . n$$

Then, we examine the output-oriented BCC model. In this model, the goal is to find the maximum output that can be produced with the maximum output of the same input. Thus, the goal is to solve the linear programming

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problem. The output -oriented BCC model is defined as shown in Equation 4:

$$Max \quad \emptyset$$
$$s.t. \quad \sum_{j=1}^{n} x_{ij}\lambda_j \le x_{io}. \qquad i = 1. \ldots . m$$
$$\sum_{j=1}^{n} y_{rj}\lambda_j \ge \emptyset y_{ro} \qquad r = 1. \ldots . s$$
$$\sum_{j=1}^{n} \lambda_j = 1$$
$$\lambda_j \ge 0. \qquad j = 1. \ldots . n$$

Equation 4

Malmquist index

In 1953, Stan Malmquist, Swedish economist introduced Malmquist index as the standard of life index. Then, in 1982, it was used for the first time in the theory of production by Kius, Christensen and Divert. In 1989, Farr et al. used data envelopment analysis method to calculate the Malmquist index and in 1994, they divided this index into two factors of change in efficiency and technology [32,33]. The calculated numbers for the distance functions are the technical efficiency obtained from the data envelopment analysis equations. Thus, the Malmquist productivity index is defined based on the maximization between two periods t and t+1, based on the common efficiency frontier at time t as shown in Equation 5:

$$M_0^{\square}(Y_t.X_t.Y_{t+1}.X_{t+1}) = d_0^{t+1}(Y_{t+1}.X_{t+1})/d_0^t(Y_t.X_t) \times [(d_0^t(Y_{t+1}.X_{t+1})/d_0^{t+1}(Y_{t+1}.X_{t+1})) \times (d_0^t(Y_t.X_t)/d_0^{t+1}(Y_t.X_t))]^{(1/2)}$$

Earned value management

Earned value management is one of the most fundamental cost control techniques and is a method of measuring and evaluating the actual progress of a project in accordance to the work, time, and costs. This method helps to evaluate the productivity of the project by comparing the primary plan and the actual progress. Earned value management has three main indicators as:

1. Actual costs on activities. This parameter is defined as cumulative and current. Cumulative activity actual costs are the sum of the actual costs of the activities accomplished to date. The actual costs of the present activity are the actual costs of the activities conducted in a certain period, in the form of days, weeks, months, etc., and are called as AC.

2. The earned value of the work that has been performed so far and is defined cumulative and current and is calculated using the following formula:

EV= estimated budget of the activity x percentage of actual progress of the activity

3. The planned value is the approved budget for the works that are supposed to be completed by the given date. This parameter is defined as cumulative and current. The cumulative planned value is the approved budget for the activities accomplished to date. The current planned value is the approved budget for the activities planned for a certain period of time and is calculated using the following formula:

PV = Activity estimated budget x percentage of the planned progress of activity

Cost performance index: Perhaps the most important index in this technique is an index to show the efficiency of using resources in the project. The cost performance index is the ratio between the earned value and the actual cost.

$$CPI=\frac{EV}{AC}$$

Schedule performance index: the ratio between the budget for the work completed and the approved budget for the work that was planned first.

$$SPI=\frac{EV}{PV}$$

These indicators define how the project team has used time efficiently. In some cases, the time performance index with the cost performance index is used to predict the estimations of project completion.

Research findings

In this study, the data is analyzed using the data envelopment analysis method and the Malmquist productivity index. These data were collected with a questionnaire and include the active bridge construction projects of Shiraz municipality in 2022. Urban projects of Shiraz municipality are implemented in three large-scale groups with medium and small-scale urban effect at the level of regional municipalities. 220 key projects were identified in eleven regions, out of which 4 projects are bridge construction projects. 50 important projects will be operated by the end of 2022. After identifying the variables, the given information was collected using questionnaires from the project in Shiraz Municipal Civil Engineering Organization. After library studies, 3 inputs including: cost, risk and importance of the project and 4 outputs including: earned value, project cost performance index, project schedule performance index and quality were determined.

Research variables

A) **Estimated budgets for each project**: The budget of a project is the hybrid costs of the activities, tasks and milestones that the project should consider and includes the amount that you need to complete the project and should be approved by all stakeholders. The estimated budget of each project is shown in Table 1. Chart 1 shows the estimated budget of each project.

B) **The actual cost of the work completed (ACWP):** It is the actual cost paid for the work performed during the project update period. Table 2 indicates the actual cost of work performed so far in 4 bridge construction projects of Shiraz Municipality in 2022.

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Table 1: Estimated budget of each project

Project	Estimated budget (Billion Rials)
A	400
B	145
C	55
D	560

Table 2: The actual cost of the work performed (ACWP)

Project	Actual cost of performed work (Billion Rials)
A	27.771
B	137.341
C	31.384
D	209.672

C) Project risks: Project risks include: delay in receiving equipment, events in the project, low expertise of the labor, lack of budget, sudden increase in the price of materials, and the shortage of manpower. In this research, risk is calculated using the FMEA method. In this method, 1-10 is considered for all failure modes in the table, and a degree of severity is dedicated to each failure mode. The risk priority number is calculated for each failure mode, which is obtained by multiplying 3 indicators of effect intensity, probability of occurrence, and diagnosis, and finally, mathematical hope is computed for each project. Table 3 demonstrates the risk status for each project. Among all the projects, project B has the highest risk and project A has the lowest risk.

Table 3: Risks of each project

Project	Risk
A	123
B	211.5
C	148.833
D	132

D) **Coefficient of importance of attaining goals**: Table 4 indicates the coefficient of importance of achieving goals as: coefficient of importance of time and coefficient of importance of cost. In this study, a score from 0-100 is assigned to each score coefficient, and the importance coefficient is the average of the two mentioned coefficients.

E) **Value of earned work:** Table 5 indicates the earned value of work in the project. Earned value means the value or budget of the work that has been accomplished so far and is obtained by multiplying the actual progress percentage of the activity by the estimated budget.

K) **Project cost performance index (CPI)**: Table 6 demonstrates the cost performance index in the project. It can be found that how much the performance of the project is in accordance with the cost plan approved by the project budget. The project cost performance index is obtained by dividing the earned value by the actual cost of the work performed.

Table 4: Coefficient of importance of achieving project goals

Project	Time importance coefficient	Cost importance coefficient	The coefficient of the importance of fulfilling the project goals
A	40	60	50
B	40	80	60
C	40	60	50
D	40	60	50

Table 5: earned value

Project	Earned value
A	286.84
B	59.8415
C	24.288
D	289.125

Table 6: Project cost performance index

Project	The cost performance index of project
A	10.3287
B	0.4357
C	0.7738
D	1.3789

H) **The schedule performance index**: Table 7 demonstrates the project schedule performance index. This index is divided by the earned value by the value of the planned work, which is obtained by multiplying the estimated budget of the project by the progress percentage of the activity planning.

Table 7: Project schedule performance index

Project	The schedule performance index of project
A	1.0457
B	0.7635
C	1.0718
D	0.5156

F) **Presented quality:** Table 8 shows the quality provided in the project as: selection of appropriate standards and methods for construction and implementation, quality control of works, technical

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knowledge and awareness, precision in financial and physical estimates, quality of supplied goods, the quality of performance during the operation period, the quality of support services, adequacy of the technical employees, and the quality of reports and their record. In this study, the quality presented is obtained from the average scores given to the mentioned items, which are given 1-100 scores to each of them. In this study, 4 active bridge construction projects of Shiraz municipality have been examined. In Table 9, the input and output data of the projects in the first stage are collected as follows:

Table 8: Quality provided in the project

Project	Presented quality
A	75.555
B	84.444
C	90
D	59.444

Table 9: Project input and output data

		Inputs			Outputs			
No.	Project	Actualized cost (Billion Rials)	Importance coefficient	Risk coefficient	EV	CPI	SPI	Quality coefficient
1	A	27.771	50	123	286.84	10.3287	1.0457	75.555
2	B	137.341	60	211.5	59.8415	0.4357	0.7635	84.444
3	C	31.384	50	148.833	24.288	0.7738	1.0718	90
4	D	209.672	50	132	289.125	1.3789	0.5156	59.444

The relationship between the results obtained with the used resources is called efficiency. In efficiency, we look for the relationship between resource consumption and actions. The more we can do and complete a work with fewer resources, we have high efficiency. Efficiency is measured based on the amount of resources used to perform a specific activity, and increasing efficiency, which is sometimes called efficiency in engineering literature, means reducing the waste of resources in performing an activity. Table 10 indicates the efficiency of bridge construction projects of Shiraz municipality.

Table 10: The Table of efficiency of bridge construction projects of Shiraz municipality

Project	Technical efficiency	Managerial efficiency	Scale efficiency
A	1	1	1
B	0.8	0.833	0.961
C	1	1	1
D	1	1	1
Overall bridge construction projects	0.950	0.958	0.990

The Malmquist index is a two-dimensional index evaluating the change in performance over time. It is an index that shows the productivity growth of the total factors of a decision-making unit, as it reflects the progress or regression in efficiency along with the progress or regression of frontier technology over time in the context of multiple inputs and multiple outputs. Table 11 is the productivity table based on Malmquist index separately for each project. Table 12 is the productivity table of all projects based on the Malmquist productivity index. **Conclusion and Recommendations**

Key project indices are measurable criteria that indicate the efficiency and success of the organization in attaining its goals. Organizations at different levels apply key performance indicators to evaluate their success in achieving their goals. At high levels, these indicators focus on overall business performance. The focus of key performance indices is on the lower levels of the process of different sections such as human resources, sales, marketing, etc. There are quantitative measurement tools that can be used to measure the quality and quantity of project activities that can influence the project's organizational goals. Therefore, one of the most important competitive advantages of organizations is efficiency and effectiveness in project management. In order to improve this competitive advantage, it is required for all organizations to control their projects by defining and using standard key indicators and to be aware of the weak and strong points of their project and to take the necessary corrective measures if necessary. The fourth chapter calculates the technical efficiency, management and the scale of bridge construction projects of Shiraz municipality, and after calculating the efficiency of projects A, C and D with the technical efficiency value of 1, they indicate that the technical efficiency is more observed in these three projects and

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show that the ability of the projects to maximize the amount of production is according to the production factors and the lowest technical efficiency is related to project B. Projects A, C, and D have a management efficiency 1, which has the highest amount of management efficiency, which shows the hard working, effort and good thinking of the management in these projects.

Table 11: Productivity based on the Malmquist index for each project

Project	Malmquist productivity index
A	1.047
B	0.860
C	0.917
D	1.065

Table 12: Productivity of all projects based on Malmquist productivity index

Project	Technical efficiency based on CRS	Technical efficiency	Technical efficiency based on vrs	Scale efficiency	Total productivity
Overall projects of bridge construction of Shiraz Municipality	1.039	0.968	1.029	1.009	1.006

Also, project B has the lowest value of management efficiency with a value of 0.833. Projects A, C, and D have the highest scale efficiency value, which is equal to 1, which demonstrates the cost reduction from economies of scale in these projects because the economies of scale are greater due to the division of labor and creation of expertise in human resources and, technological factors reduce costs and increase efficiency. Project B has the lowest scale efficiency with a value of 0.961. Units A, C, and D were determined effective units, and unit B was determined ineffective unit. In most cases, the terms productivity, efficiency and effectiveness are used inappropriately or confused. Improving efficiency does not guarantee productivity improvement. People often think that if efficiency is improved, productivity is increased. Efficiency is a necessary condition of productivity, but it is not sufficient. In fact, to have high productivity, both effectiveness and efficiency are required. Efficiency is the ratio of the actual product (or services provided) to the expected product, while effectiveness is the degree of attaining goals in the organization, and productivity is the total efficiency and effectiveness. That is, the concept of productivity includes the two concepts of effectiveness and efficiency: (productivity = effectiveness + efficiency). Productivity is a combination of efficiency and effectiveness that emphasizes both quantitative and qualitative aspects and is the ratio of the output to the input used in it. Efficiency and effectiveness are intertwined in every economic enterprise or industrial group, because it is possible that an economic enterprise or an industrial group is efficient, but the presented product does not have the necessary desirability, or the level of achieving the goals is low. Thus, it is said that the economic enterprise or industrial group is not effective, and it is possible that enterprises or groups can attain the goals, but at a very high cost, which again means that the economic enterprise or industrial group is not efficient. Project D with a value of 1.065 has the highest productivity value and project B with the value of 0.860 has the lowest productivity value. Considering the following factors and criteria as the main factors affecting the efficiency, effectiveness and productivity of production and economic enterprises can be very effective. This is because these factors are part of the internal factors of the companies and they are mainly controlled by the owners of the companies such as: hardware factors: machinery and equipment and tools, technology, raw materials, financial resources and land, software factors: information, instructions, maps and formulas, man-oriented or brain-based factors, labor, capability, expertise, experience, education, motivation, work environment, etc. Management behaviors, management philosophy and style, access to information technology show that in general, factors such as cost, planning, risk, quality and safety can influence project results and any one of these factors can cause weakness in the project.

Recommendations

With the increase of industrial and service projects all around the world, earned value management as a new and efficient method plays a crucial role in the integrated project control. One of the main concerns of project managers and stakeholders is to know exactly the progress and compare the amount of work accomplished with the amount of work predicted and

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calculate the cost and time contradictions with the actual performance. There are always some limitations in the accurate assessment of the amount of work performed in the project, but without measuring and evaluating the progress of what has been done, the project cannot be controlled. The most common method of measuring the project is via the analysis of variance or added value, and analysis of deviation from the schedule. It allows the project manager to identify the problems and barriers of the project and take the necessary measures to eliminate the obstacles. There are three main elements in every project that the project manager should control. In order to achieve quality goals, special mechanisms should be considered in order to achieve quality goals, to ensure the achievement of these goals, but regarding goals (early and cheap)(control of time and cost contradictions), the discrepancy between the predicted time and the completed time, as well as the predicted cost, should be identified and evaluated at pre-defined times and its effect on the entire project should be clearly defined. In order to keep the project more economical and use the allocated budget efficiently, the project manager should regularly control the actual costs of the activities and identify the causes of deviation from the predicted values and act in accordance to achieve these goals. Given the role and importance of earned value management and its indicators in projects, it is recommended that this issue be taken into consideration by project managers.

In order to achieve research and development in future studies, it is recommended to apply other methods and tools to calculate efficiency and also use different variables that may change the results of efficiency. This study used bridge construction projects of Shiraz municipality, which is suggested to be used from other projects of Shiraz municipality including: green space projects, etc. In this paper, Deap software was used to calculate efficiency and Malmquist productivity index, which is recommended to apply other software as GAMS, etc.

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