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How to Target Balanced Scorecard Indicators in a DEA-BSC Integrated Model

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Abstract

Performance measurement is always one of the most important tasks of managers, so knowledge management is measurement knowledge, and if we can measure something, we can no doubt control it, and therefore we cannot manage it. In this paper, according to the Malmquist productivity index, an index is used to determine the progress and regress of a unit. This index is defined by the boundary changes resulting from the inputs of the units and their efficiency changes, which we call the Malmquist Productivity Index. After calculating the Malmquist changes, we were able to determine the rate of increase or decrease in the indicators for the following period.

Keywords: Data Envelopment Analysis, Balanced Scorecard, Malmquist Productivity Index.

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1. Introduction

Strategy is the major source of long-term growth for organizations. It also identifies the major obstacles and problems associated with strategy at the stage of strategy implementation and implementation. This is in vain if the strategy is not successfully implemented, even if proper strategies are adopted.

Following the development and evolution of human knowledge in economics and management, the concepts of efficiency and productivity have also been developed, and in the last two decades, its measurement has been made possible through practical economic theories. In the new definition, efficiency is the concept of not wasting resources, which is derived from the ratio of total output to total inputs. Productivity is the concept of comparing the efficiency of one firm at two different times or comparing the efficiency of two firms at a time. In other words, productivity is the comparison of efficiency. The Malmquist Productivity Index is one of the most recent methods of measuring productivity. Prior to the development of the Malmquist Productivity Index, only performance changes were the measure of improvement or regression, but technical changes were also found to be effective in productivity [1], [2].

Correctly calculating organizations' performance and performance appraisal is now one of the most important macro management issues. It is clear that the more accurate this calculation is in keeping with the overall goals of the organization, the more accurate the decisions taken for the future of the organization to pursue its strategic goals. [3-7].

On a balanced scorecard, all strategic goals should have support measures. Similarly, all measures should have a quantitative goal. Setting quantitative goals is rooted in the organization's vision statement. In the vision statement, top management defines a great and ideal goal for the organization. This goal creates a gap between current operational processes and the organization's cause [8], [9], [5]. The strategies of the organization need to be designed in such a way that they can fill the gap. Senior managers have a responsibility to bridge the gap created by explaining the more detailed and quantifiable goals that result from the organization's strategies. Therefore, quantitative objectives can express the relative impact needed to execute strategies operationally. [10-12].

Managers should note that the quantitative goal, ie the amount of performance that an organization believes in at a given time, must be met. We need to know that targeting and forecasting are completely different. Quantitative and predictive goals are not and should not be the same. The quantitative goal is the dream you want to achieve. Prediction is what you expect to achieve. So to manage and assign them you have to have different numbers and different processes. When artificially pairing quantitative and predictive goals together, you may have either chosen or predicted bad quantitative goals, or often both [13], [14], [2].

Quantitative objectives should clearly and clearly represent the intended performance expectations of the organization. Therefore, they should be based on an analysis of expected performance and internal capabilities of the organization. In other words, the quantitative objectives in the Balanced Scorecard management system should reflect the necessary changes in performance. Performance enhancement should also be commensurate with quantitative goals [15].

The fundamental question of research is how to provide a way to address the shortcomings of the traditional quantitative targeting process in a

balanced scorecard, a way to set quantitative goals based on prior real data, and consider the goals that the organization wants for the big goals.

2. Literature Review:

2.1. Malmquist Productivity Index:

Using linear programming technique and data envelopment analysis, Farrell defined an appropriate method for evaluating empirical production function for multi-input and multi-output in data envelopment analysis. The decision-making units are obtained the decision-making units on the performance boundary are the units with the highest output level or the lowest input level. By integrating each unit efficiency change and technology change, the Malmequst Productivity Index is defined as the Malmequst Productivity Index. Or calculate other similar functions:

$$D(X_p, Y_p) = inf\{\theta/(\theta X_{p,} Y_p) \in PPS\}$$

The above relationship in very specific cases only shows the efficiency boundary changes at t + 1, relative to the efficiency boundary at moment t, and cannot be a suitable criterion for calculating technological changes, and efficiency changes are also ignored in this method. If so $D^k(X^k,Y^k)=1$ the k efficient unit is then assumed to be ineffective. This function does not specify the amount of inefficiency Farrell divides the productivity index into two factors due to the inefficiency and linearity of the technology boundary. The production function is assumed at time t and t + 1 and to solve the Malmquist index we solve the four linear programming problems as follows.

$$D^t(X_p^t, Y_p^t) = min \quad \theta$$
$$s.t. \quad \sum_{j=1}^{n} \lambda_j x_{ij}^t \le \theta\, x_{ip}^t \quad , \quad i = 1, \dots, m$$
$$\sum_{j=1}^{n} \lambda_j\, y_{rj}^t \ge y_{rp}^t \quad , \quad r = 1, \dots, s$$
$$\lambda_j \ge 0 \quad , \quad j = 1, \dots, n$$

That -i x_{ip}^t entrance -r y_{rp}^t Output from DMUp is in the age of t.

Performance value $D^t(X^t,Y^t)=\theta$ Indicates how much can be input DMUp Subtracted to produce the same output over time t Issue CCR For time t+1 $D^{t+1}(X^{t+1},Y^{t+1})$ That technical efficiency DMUp is in the time of t+1 Obtained The amount of $D^t(X^{t+1},Y^{t+1})$ for DMUp that's the distance DMUp in the time of t+1 is By the border t The following linear programming problem is obtained:

$$D^t(X_p^{t+1}, Y_p^{t+1}) = min \quad \theta$$
$$s.t. \quad \sum_{j=1}^{n} \lambda_j x_{ij}^t \le \theta x_{ip}^{t+1} \quad , \quad i = 1, \dots, m$$
$$\sum_{j=1}^{n} \lambda_j\, y_{rj}^t \ge y_{rp}^{t+1} \quad , \quad r = 1, \dots, s$$
$$\lambda_j \ge 0 \quad , \quad j = 1, \dots, n$$

Similarly $D^{t+1}(X^t,Y^t)$ space DMUp with coordinates t Relative to the efficiency boundary t+1 it is calculated that to calculate the Malmquist productivity index in the input nature, this value is the optimal solution to the following linear programming problem.

$$D^{t+1}(X_p^t, Y_p^t) = min \quad \theta$$
$$s.t. \quad \sum_{j=1}^{n} \lambda_j x_{ij}^{t+1} \le \theta x_{ip}^t \quad , \quad i = 1, \dots, m$$
$$\sum_{j=1}^{n} \lambda_j\, y_{rj}^{t+1} \ge y_{rp}^t \quad , \quad r = 1, \dots, s$$
$$\lambda_j \ge 0 \quad , \quad j = 1, \dots, n$$

If we can assume that $D^t(X^t,Y^t)$ and $D^{t+1}(X^{t+1},Y^{t+1})$ to be effective, they must be equal to one, so relative efficiency changes can be defined:

$$TEC_p = \frac{D_p^{t+1}(x_p^{t+1}, y_p^{t+1})}{D_p^t(x_p^t, y_p^t)}$$

Definition 1: We say that a piece of the boundary has a positive motion, if and only if this piece is in time t+1 Relative to the corresponding point in time t Expand and expand production as a whole.

Definition 2: We say a piece of boundary is moving negatively, if and only if this piece is in time t+1 Relative to the corresponding point in time t The set makes it possible to make the rat smaller and move inward.

Far explains the extent of technological change between the times t and t+1 Expressed in geometric composition:

$$FS_p = \sqrt{\frac{D_p^t(x_p^{t+1}, y_p^{t+1})}{D_p^{t+1}(x_p^{t+1}, y_p^{t+1})} \cdot \frac{D_p^t(x_p^t, y_p^t)}{D_p^{t+1}(x_p^{t,} y_p^t)}}$$

The following changes occur for the technology change index:

1- FSp >1 whether the boundary movement is positive or, in other words, progress is observed

2- FSp<1 whether it is borderline movement or regression

3- FSp=1 It shows that no movement is needed or that the boundary does not change

Malmquist productivity index of input nature for each DMUp at times t and t+1 It is the result of performance changes and technology changes that are discussed below.

$$M_p = \frac{D_p^{t+1}(x_p^{t+1}, y_p^{t+1})}{D_p^t(x_p^t, y_p^t)} * \sqrt{\frac{D_p^t(x_p^{t+1}, y_p^{t+1})}{D_p^{t+1}(x_p^{t+1}, y_p^{t+1})} \cdot \frac{D_p^t(x_p^t, y_p^t)}{D_p^{t+1}(x_p^{t,} y_p^t)}}$$

And if we simplify the above equation Mp Is equal to

$$M_p = \sqrt{\frac{D_p^t(x_p^{t+1}, y_p^{t+1})}{D_p^t(x_p^t, y_p^t)} \cdot \frac{D_p^{t+1}(x_p^{t+1}, y_p^{t+1})}{D_p^{t+1}(x_p^{t,} y_p^t)}}$$

This value is defined as a convex geometrical combination because it identifies the smallest weakness in performance and the smallest change in any of the effects on the Malmquist productivity index.

1- Mp>1 Shows productivity gains and improvements

2- Mp<1 It shows a decrease in productivity and a regression is observed

3- Mp=1 Shows that no change in productivity for the times t and t+1 It has not happened.

2.2. Balanced Scorecard:

In the 1990s, the Balanced Scorecard model was first introduced as a new performance appraisal method, and then as a tool for strategy realization, or in other words, a strategy for strategy by Harvard University professor Robert Kaplan and eminent management consultant David Norton in the United States. And it was greatly welcomed by management experts and managers of organizations.

Balanced Scorecard is a management technique that helps managers evaluate the organization's growing and declining activities and processes from different angles. In fact, a balanced scorecard examines the extent to which the goals of the organization are accessible from different angles. In fact, the Balanced Scorecard describes the extent to which the goals of the organization have been reached through the policies chosen. This technique examines the effectiveness of an organization's strategies by identifying the achievement indicators.

Conventional methods of evaluating prior performance focused primarily on the financial aspects of the organization and focused on its indicators, but the Balanced Scorecard expanded its indicators to the four perspectives of finance, processes, customer learning, and human resource development, and sought to create a balance between Financial targets are the result of past performance (past Necker indices) and three other indices (futures indices)

A successful way of applying a balanced scorecard is to use the BSC as a tool for designing performance evaluation indicators and then measuring the indicators over an appropriate and desired timeframe from the four main BSC approaches.

If we are to summarize the four points of the Balanced Scorecard system, the following questions must be answered:
Financial side:
What are the stakeholders' expectations of the organization? And what goals, measures, and programs are needed to meet stakeholder expectations.
Customer side:
What are the customers' expectations and expectations from the organization? And what goals and plans are needed to meet customer expectations.
Internal processes side:
What actions should be taken to meet the demands and expectations of customers and then shareholders? Happen? And what are the key processes to do these activities?
Growth and learning side:
The needs of customers, stakeholders and stakeholders have been identified and the processes that should meet those needs have been identified. So who should do these activities and processes? What are the capabilities and capabilities of human resources, information technology, and organizational infrastructures to make things work efficiently and effectively?

3. Research methodology

In the Balanced Scorecard method, because the relationship between the strategic goals of the bottom layers with the top layers is not completely clear, it is not clear which strategic goals are related to each other and thus affect each other. It is important to clearly represent the goals and strategies of the organization.
In order to draw a strategy map, we use correlation analysis to find links from the bottom up. We actually determine their relationship through the amount of impact that different goals have on each other. Strategic aspects are outlined in the various aspects of the Balanced Scorecard method, and the relationships between the different layers are clarified and it is clear which strategic goals are related to the four sections of the Balanced Scorecard.
The following are the steps to take:

1- Using the correlation analysis method:
Using the correlation analysis of the relationships between the strategic goals of the four aspects of finance, customer, internal processes, and learning and growth, we use bottom-up strategies and draw a strategy map using these correlations.

2- Investigating the relationship between different aspects using regression equations:
We know that there is a kind of cause-and-effect relationship between the goals and indicators in the four aspects of the Balanced Scorecard that links them together since there may be some relationships in the strategic map that can be analyzed using the correlation analysis of these relationships. Not specified at this stage, using the regression relationships and the relationships between the strategic goals of the customer aspects, internal processes, and learning and growth with the strategic goals, we identify the strategic goals defined in the financial aspect as dependent variables and goals. We consider the variables as independent variables and form the regression equations for the other aspects according to the principle.

3- Draw a strategy map using correlation and regression analysis:

4- Formation of regression equations taking into account the relationships of the strategy map:
After identifying the relationship between goals but not determining the extent of these relationships, we determined the relationship from bottom to top by using

regression method to determine the extent of these relationships and to what extent strategic goals influence each other.
For example, from the highest aspect that is the financial aspect, we have identified the relationship between the strategic goals defined in this aspect with the other sectors as well as the other goals defined in this aspect, which should form the regression equation.

5- Forming a regression equation between the amount of performance and goals in the financial domain:
In the preceding section, equations related to efficiency calculations were introduced. Undoubtedly, the goal is to maximize the financial results in the organization. The relationship between efficiency and financial goals is undeniable. We specify the financials on the efficiency.

6- Set quantitative performance goals commensurate with the Malmquist index:
For units with technical inefficiencies, the goal should be to make them efficient and deliver the units to MPSS value, given the unit's performance rating in DEA-assisted measurement, and carefully in the process of moving the organization over previous periods to assist. The Malmquist Index is a quantitative target for the next period to improve the performance status of the unit under evaluation.

7- Set quantitative goals:
Using the regression equations obtained between efficiency and goals in the financial domain, we can determine the rate of increase in each of the goals in the financial domain. Their effect on each other and to what extent are the effects of each other's quantitative objectives are obtained for different goals in different domains is).

8- Model Implementation:
In the first step, the four areas of Balanced Scorecard are developed in accordance with the Executive Structure Algorithm for the target bank.

Strategic Goals		
Refund facility rates	F1	Financial field
Return on capital	F2	
Profit margin	F3	
Cost to income	F4	
Deferred Facility Rates	F5	
Competitive pricing	C1	Customer Domain
Customer Satisfaction	C2	
High quality service	C3	
Customer attraction rate	C4	
High speed service	C5	
Increase service speed	I1	Internal Processes
Online services	I2	
Electronic services	I3	
Advanced Services	I4	
Motivational costs	L1	The field of learning and growth
Increasing staff expertise	L2	
Increase the skills of the staff	L3	

4. Results

We know that total efficiency is a function of the performance of different areas of the organization being evaluated. It means:

$\theta_{overal} = f(\theta_1, \theta_2, \theta_3, \theta_4)$

θ_1 - Financial Field Performance

θ_2 - Customer domain efficiency

θ_3 - Internal process domain efficiency

θ_4 - Learning and growth Area efficiency

Therefore, in addition to the total efficiency, the computational efficiency of the individual domains has also been calculated because having the details of the efficiency, the weaknesses of the organization in each of the domains have been identified and we can easily criticize the causes of our inefficiency. Also, the amount of investment in each of the areas of the balanced scorecard can be determined by their performance score.

The following table presents the results of the calculation of eleven banking units for the year 94. Similar calculations have been made for other years.

Performance calculated in 2015

	Efficiency				
	Learning and Growth Area	Domain of internal processes	Customer domain	Financial field	Overall efficiency
DMU1	0.929	1	0.795	0.405	0.579
DMU2	0.681	1	0.851	0.610	0.598
DMU3	0.657	1	0.932	0.679	0.563
DMU4	0.386	1	1	0.177	0.357
DMU5	0.406	1	0.81	0.181	0.386
DMU6	0.745	1	0.699	0.873	0.743
DMU7	0.668	1	0.766	1	0.594
DMU8	0.616	1	0.755	0.507	0.537
DMU9	0.58	1	0.953	0.474	0.512
DMU10	0.662	1	1	1	0.662
DMU11	0.695	1	0.932	0.984	0.678

None of the domains have been combined according to the performance table, which can be attributed to the weakness of their subunits. According to unit number 4, it has the least performance, although it has performed very well in the two domains, but the weakness Over-learning in the areas of learning and growth (0.386) and financial (0.177) has made total efficiency to reach the lowest value (0.357) in the next step.

Using correlation analysis and regression relationships, the strategy map between goals and areas of balanced scorecard was plotted. The following table shows the factors affecting each of the goals of different points of scorecard.

Effective Factors Balanced Scorecard Characteristics

Strategic Goals	Effective Factors
F1	C1 , C4 , C5 ,I4
F2	C1 , I1 ,f4
F3	F1 , F4 , F5 , C3 ,C5
F4	C2 , C3 , C4, F5
F5	C3 , C4
C1	……..
C2	C3 , C5 , I3 , I4
C3	L1 , L2 ,L3 , I4
C4	C1 , I3
C5	I3 , I4 , L2 , L3
I1	I2 , I3
I2	……..
I3	I2 , L2
I4	I1 , L1 , l2

As it can be seen from the table above, the F1 strategy goal is related to the C1, C4, C5, and I4 strategy goals, so F1 is a dependent variable and the other strategic goals associated with it as an independent variable will be similar to the rest of the goals. We are now writing regression equations for strategic purposes:

Regression equations related to the strategy map

Regression equations	Correlation coefficient (R2)
F1=2.995C4 +0.364I4	0.67
F2=0.06I1	0.55
F3=6.94C3+0.362F5	0.75
F4= 16.68 – 9.132F5	0.85
C3=-2.69 +0.2L1	0.92
C4=16.29+0.018I3+0.21C1	0.57
I1=0.508I3	0.93
I3=1423+45L2+3.94I2	0.90
I4=0.056I1+0.574L1	0.83

To determine the quantitative target for efficiency, we need to examine the past trend of the units under evaluation. Therefore, the Malmquist index is used as a powerful tool for past review. The movement trend of the organization during the years 5 to 8 shows the first units.

Calculate the Malmquist index of unit I

	85-86	86-87	87-88	88-89	89-90	90-91	91-92	92-93	93-94	94-95
Performance changes	1.133	0.869	1.128	1.264	1.429	1.073	1.087	1	0.961	0.743
Technology changes	0.858	1.114	0.965	0.924	0.779	1.144	1.383	0.78	0.916	1.438
Malmquist	0.972	0.969	1.089	1.169	1.114	1.229	1.504	0.78	0.88	1.069

Looking at the changes in Malmquist Index and the two indicators of technology changes and efficiency changes related to Unit 1, it can be said that the unit has not performed well in the field of efficiency over the last three years, and the

improvement of Malmquist Index has only been due to an increase in technology changes. It has been concluded that for the next period there can be no significant increase in efficiency improvement. Preservation of the status quo and a slight increase in efficiency may be the best case for the unit.

Now with small amounts in the financial aspect, given the regression relationships identified between strategic goals and other aspects, we can determine the amount of changes in their quantitative goals, in fact having a set of strategic goals in the financial aspect, the quantitative goals of others. Here are some aspects of how to calculate unit calculations

Predictive values for future targets for strategic indicators

Increase in financial goals				Increase in customer goals				Increase in goals Internal processes				Increase in goals Learning and growth			
	Previous period		Prediction		Previous period		Prediction		Previous period		Prediction		Previous period		Prediction
F_1	17.07	F_1	17.477	C_1	19.97	C_1	20.47	I_1	1124	I_1	1191.16	L_1	16.42	L_1	30.27
F_2	13.2	F_2	17.15	C_2	3.34	C_2	3.54	I_2	1045	I_2	1395	L_2	12.14	L_2	14.12
F_3	5.38	F_3	6.155	C_3	3.72	C_3	3.80	I_3	2025	I_3	2157.2	L_3	36.16	L_3	38.1
F_4	39.17	F_4	49.76	C_4	20.47	C_4	36.86	I_4	90	I_4	135.29				
F_5	9.18	F_5	9.847	C_5	3.32	C_5	3.54								

5. Conclusion:

Considering the research problem that is a method for considering quantitative goals based on past real data in the balanced scorecard, in this paper, using the data of ten prior periods in the form of Malmquist index of eleven decision makers, four criteria are separated. Financial, customer, internal business processes, and learning and growth are calculated using data envelopment analysis.

To determine the quantitative objectives for each strategic objective, the efficiency of the various units for the next period has been determined.

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