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Performance Evaluation of Regional Power Distribution using a BSC-ANP Hybrid Approach

Abstract

The aim of this research is to evaluate the performance of regional power distribution using a Balanced Scorecard (BSC) model. Measurement indicators aligned with the operational objectives of the studied power distribution company were selected and mapped onto the company's strategic map. Experts and specialists reviewed and refined these indicators in the four perspectives of the Balanced Scorecard. Combining the model with Analytic Network Process (ANP) analysis process not only addressed the weighting problem for evaluation indicators but also resolved the issue of neglecting the existence of interdependencies and feedback loops between perspectives and indicators under each perspective. The results indicate that, according to the officials and experts of the company, financial, customer, internal process, and growth and learning perspectives are of importance in descending order among other perspectives. Using quantitative data and calculating the weighted achievement percentage, the final performance score of Zones one to seven was obtained. It shows that the company had good performance in Zones two, three, and seven, while it had average performance in Zones one and five, and weak performance in Zones four and six. Regarding the overall priority of the indicators, it was determined that the average duration of subscriber outages holds the highest importance, while the number of incident points resolved holds the least importance in assessing the company's performance.

Keywords: *Performance Evaluation; Analytic Network Process; Balanced Scorecard.*

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Introduction

Understanding an organization's performance level is a prerequisite for improving its performance. Measuring performance and subsequently identifying the strengths and weaknesses of the organization, along with refining plans and objectives, will lead to increased efficiency. With growing competition in production and services, organizations have found the need for metrics and patterns to assess their performance. The shortcomings of traditional measurement standards and changing competitive environments have prompted the redesign of performance measurement systems in organizations. This is particularly crucial in ensuring sustainable and economical power distribution for the development and well-being of society. Given the diverse goals of the power industry, traditional models and financial indicators alone cannot depict the performance of this industry. One successful tool in implementing strategic plans for organizations to achieve a new performance measurement system is the Balanced Scorecard (BSC) system [12]. The Balanced Scorecard model essentially presents a diverse set of performance indicators in four perspectives (groups): financial, customer, internal business process, and growth and learning [5]. This research aims to evaluate the performance of Zones one to seven of Shiraz Power Distribution using the BSC approach. In this study, the BSC model is combined with the Analytic Network Process (ANP) approach to incorporate the opinions of company managers and experts and determine the share and priority of perspectives and indicators under each perspective. In addition to

addressing the weighting problem for evaluation indicators, the ANP analysis process also resolves the issue of neglecting the existence of interdependencies and feedback loops between perspectives and indicators under each perspective [13]. Finally, by incorporating quantitative values and calculating the weighted achievement percentage, the final performance score of the seven zones will be determined.

Research Background

The Balanced Scorecard (BSC) is a management technique that assists managers in examining the activities and the trajectory of an organization from various perspectives. This technique provides managers with a comprehensive framework to interpret and translate the company's vision and strategy into sets of performance indicators.

The Financial Perspective encompasses financial performance indicators that demonstrate the impact of the company's strategy, the execution and implementation of actions for profitability in business units. The Customer Perspective includes aspects such as customer satisfaction, customer feedback, acquiring new customers, and the time required to respond to customers. Ultimately, it addresses what customers expect from the organization.

The Internal Business Process Perspective allows managers to identify the most critical processes necessary to achieve customer goals and organizational profitability. The Growth and Learning Perspective answers the question of whether the organization can create and sustain a process of improvement. It focuses on explaining the success of the organization based on the future success of its individuals and structure.

The core of the Balanced Scorecard is formed by the vision and strategy. These two elements essentially serve as the foundation for shaping the four aspects of the Balanced Scorecard, and financial results are achieved when the organization's efforts in the other three areas are well-guided.

Conceptual Model of the Balanced Scorecard

The company has developed strategies to achieve operational objectives. In the conceptual model of the balanced scorecard of the electricity distribution company according to Figure1, In this table

Strategies of the financial dimension:

(increase in other incomes,
Reducing the cost of providing services,
timely collection of claims)

Customer dimension strategies:

(updating commitments, recruitment,
blackout reduction)

Strategies after internal processes:

(replacing electromechanical meters,
continuous testing and inspection of measuring equipment,
Speed in installing measuring devices,
consumption management and peak load reduction with emphasis on cooling load control,
Identifying and converting unauthorized electricity into branching,
Renovation of worn-out substations,
Reducing areas with voltage drop,
increase maneuver points)

Strategies for growth and learning:
(Fixing network accident points,
occupational health and safety management)
Is considered.These strategies are guiding principles for achieving the company's goals, and with the help of the company's strategic map and the re-evaluation by experts and specialists in the perspectives of the Balanced Scorecard, they are crystallized into a conceptual model.

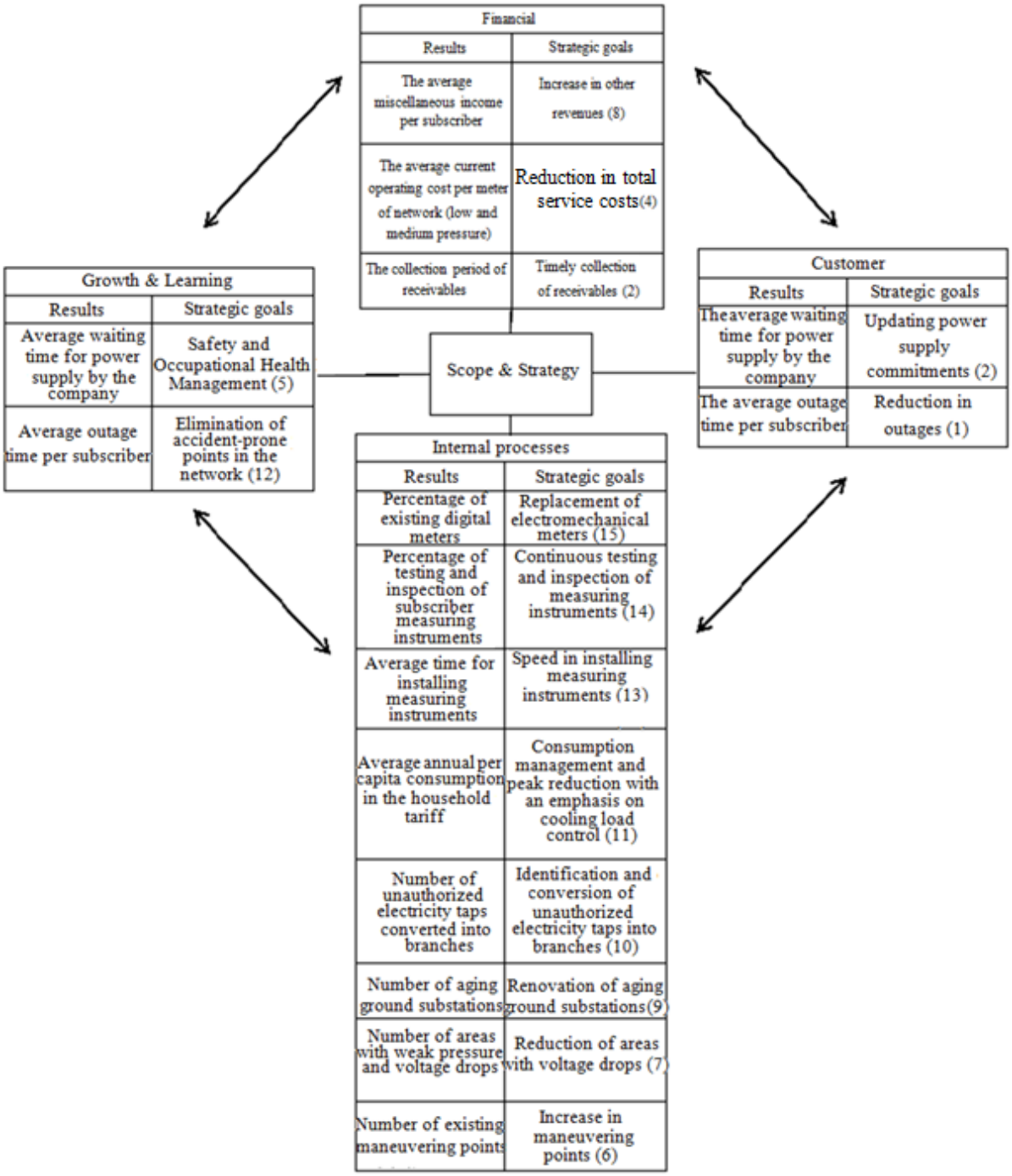

Figure 1. Conceptual Model of Balanced Scorecard for Shiraz Power Distribution Company

One of the fundamental discussions in the implementation process of the Balanced Scorecard is determining the share and weight of each performance indicator. The process of weighting and ranking performance indicators is of great importance, as these indicators must maintain a balance between long-term and short-term objectives, as well as between financial and non-financial objectives. The Analytic Network Process (ANP) introduced in 1996 provides a general framework for decision-making by considering inter-level dependencies and recursive relationships in the hierarchical structure, resulting in more reliable resource allocation [7].

Given the increasing importance of comprehensive and balanced performance evaluation of

organizations, numerous studies have been conducted in this area. Among them, the combined approach of the Balanced Scorecard with other management techniques stands out. For instance, Tajadod and colleagues used a combination of ANP and BSC in 2013 to construct a coherent decision-making model for evaluating the level of outsourcing in a company [15]. Yan Lili and colleagues in 2012 focused on prioritizing customer needs in product planning using a combined approach of the Balanced Scorecard and the Minimum Deviation method [10]. An internal analysis of organizational performance using the Balanced Scorecard and System Dynamics has been conducted in a study [2], and the combination of BSC with Data Envelopment Analysis (DEA) is also noteworthy [5]. However, in the case of this study, the implementation of the Balanced Scorecard or its combination with other techniques for the power distribution company was not found.

Research Methodology

This research is descriptive-survey and of an applied nature. The research questions are as follows:

1. To what extent is the importance (weight) of performance evaluation indicators determined?
2. How are the performance scores of Zones one to seven of the power distribution company?

Population and Sample

The population and sample during the research consisted of 8 individuals, including managers and experts of Shiraz Power Distribution Company.

Method of Determining Performance Evaluation Indicators

The studied power distribution company has formulated strategies to achieve operational objectives. Each of these strategies is measured using an indicator. These strategies, in line with the company's strategic map, have been reviewed by experts and specialists in the four perspectives of the Balanced Scorecard. In this step, it is necessary to establish the relationship between the indicators and sub-indicators. For this purpose, the company's strategic map and the opinions of experts have been used. The indicators and sub-indicators have both internal dependencies and mutual relationships.

Data Collection Tool, Validity, and Reliability

To collect the desired data, a questionnaire was used. To confirm the validity of the research questionnaire, since the questionnaire is aligned with the operational objectives and derived from the company's strategic map, its validity is confirmed. The reliability of this standardized questionnaire is assessed through the coefficient of congruence rate. In other words, if the congruence rate exceeds 0.1, the questionnaire is modified and redistributed until the pairwise comparison results reach a congruence rate of less than 0.1 [9]. In this study, the final 8 questionnaires considered all achieved a congruence rate lower than 0.1 in all pairwise comparison tables.

Determining the Final Weights of Indicators

The Super Decisions software supports the determination of indicator weights using a network model [6]. In this software, the objective, criteria, sub-criteria, internal relationships, and mutual dependencies are considered in the model. The pairwise comparison matrices are completed using the final information whose compatibility has been confirmed and is less than 0.1. The geometric mean of group opinions is the final information entered into the software [4]. The outputs of the software include the Supermatrix Non-negative, Supermatrix Positive, and Supermatrix Limit. Finally, the weights of the indicators can be obtained from the normalized Supermatrix Limit. In fact, the overall priorities of criteria and sub-criteria can be extracted from it.

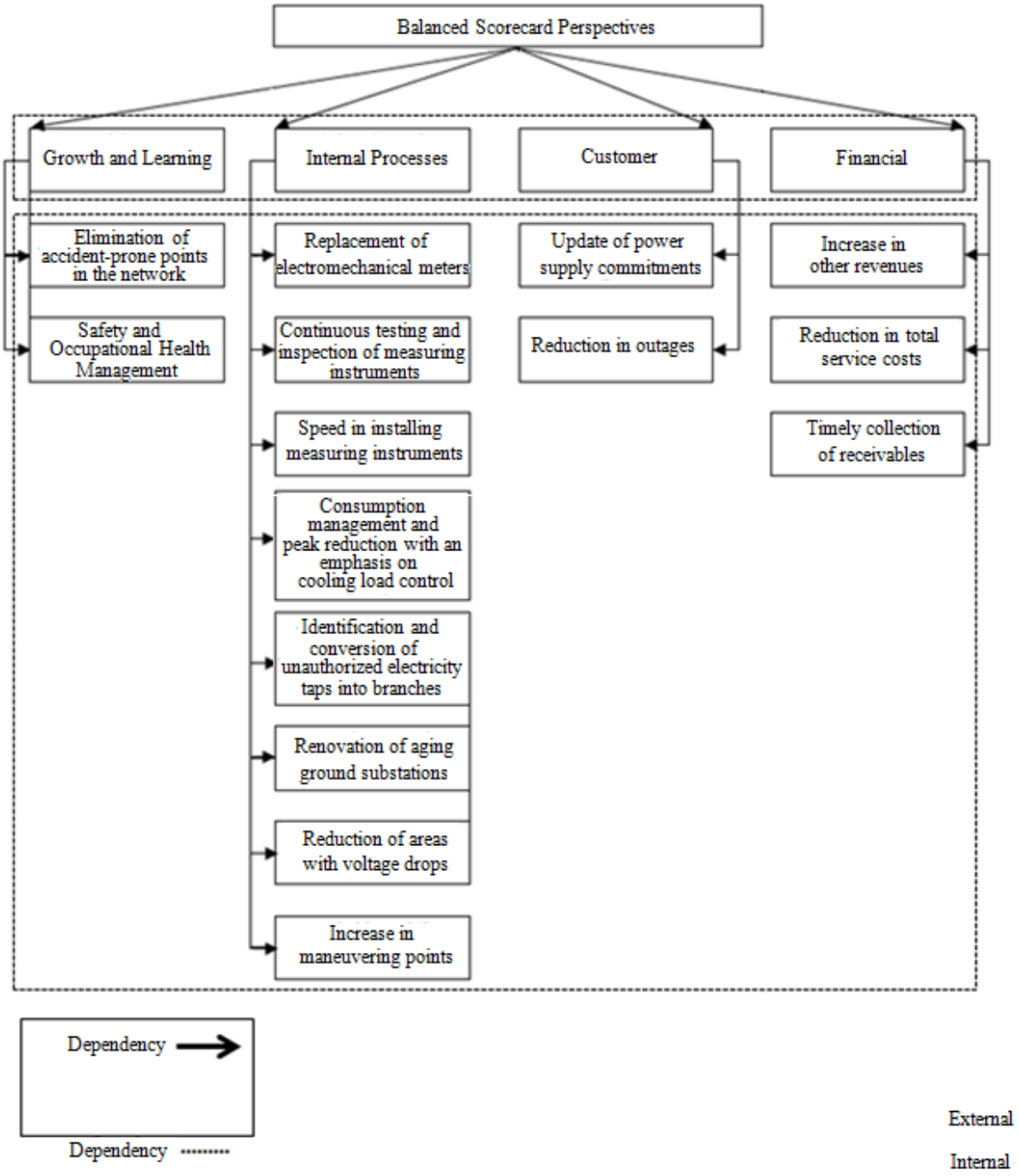

Figure 2. Network Model for Determining Performance Evaluation Index Weights

Determining the Final Performance Scores

In Table 1In this table, strategies are measured in each dimension with the following metrics:

Performance Indicator Indicator Weight Unit 2021 Quantitative Target 2021 Performance Indicator Achievement Percentage in 2021 Weighted Indicator Achievement Percentage. The example of the method of calculating the final score of performance for the region, due to the confidentiality constraints of the company, statistical information for the year 2012 has been considered. The statistical information includes quantitative objectives and the performance of indicators in each region for the year 2012. The uniformity of measurement indicators and their final weights for each of the seven regions allows for

comparison. For each indicator, the final weight is multiplied by the achievement percentage, which is the result of dividing the performance by the quantitative value of the indicator. This gives the weighted achievement percentage of the indicator in 2012. However, for negatively themed data, the reverse has been calculated. The final performance score for each region is obtained by summing the weighted achievement percentages of the indicators [3]. Below is an example table for calculating the final performance score for Region 1. The same process has been followed for other regions, and only the final results are provided.

Table 1. Sample Method for Calculating Final Performance Score for Region One

Perspective	**Strategy Name**	**Performance Indicator**	**Indicator Weight**	**Unit**	**2021 Quantitative Target**	**2021 Performance**	**Indicator Achievement Percentage in 2021**	**Weighted Indicator Achievement Percentage**
Financial	Increase Other Revenues	Average Miscellaneous Revenues per Subscriber	0.03333	Thousand Rials	39	35.5	91.02564	3.033885
	Reduce Fully Loaded Service Cost	Average Current Operating Cost per Meter of Network (Low and Medium Pressure)	0.0822	Thousand Rials	9.1	10	91	7.4802
	Timely Collection of Claims	Claims Collection Period	0.20273	Days	45	48	93.755	19.00594
Customer	Update Power Supply Commitments	Average Waiting Time for Power Supply by the Company	0.15651	Months	5	6	83.33333	13.0425
	Reduce Outages	Average Duration of	0.33782	Minutes per Year	557	817	68.17625	23.0313

Perspective	Strategy Name	Performance Indicator	Indicator Weight	Unit	2021 Quantitative Target	2021 Performance	Indicator Achievement Percentage in 2021	Weighted Indicator Achievement Percentage
		Outages per Subscriber						
Learning and Growth	Resolution of Incident-Prone Network Points	Number of Resolved Incident-Prone Points	0.00981	Count	2709	2463	90.91916	0.891917
	Occupational Safety and Health Management	Safety Management Form Score	0.04902	Score	668	557	83.38323	4.087446
Internal Process	Replacement of Electromechanical Meters	Percentage of Digital Meters Installed	0.00353	Percentage	39.9	24.8	62.15539	0.219409
	Continuous Testing and Inspection of Measurement Equipment	Percentage of Testing and Inspection of Subscriber Measurement Equipment	0.004	Percentage	100	100	100	0.4
	Speed in Installing Measurement Equipment	Average Time to Install Measurement Equipment	0.00832	Days	3	14	211.428557	0.178286
	Consumption Management and Peak Load Reduction with Emphasis on	Average Annual Consumption per Household	0.01183	Kilowatt-Hours	2315	2315	100	1.183

Perspective	Strategy Name	Performance Indicator	Indicator Weight	Unit	2021 Quantitative Target	2021 Performance	Indicator Achievement Percentage in 2021	Weighted Indicator Achievement Percentage
	Air Conditioning Load Control	in the Residential Tariff						
	Identification and Conversion of Unauthorized Electricity to Branching	Number of Unauthorized Electricity Converted to Branching	0.01304	Count	1000	1043	104.3	1.360072
	Renovation of Aging Ground Posts	Number of Aging Ground Posts	0.01671	Count	9	9	109.8592	1.835746
	Reduction of Areas with Voltage Drop	Number of Weak Pressure Areas with Voltage Drop	0.0346	Count	10	29	91	3.1486
	Increase in Maneuver Points	Number of Existing Maneuver Points	0.0346	Count	84	74	88.09524	3.048095
Total	**Final Performance Score for Region One**	-	-	-	-	-	-	**81.9464**

Data Analysis and Research Findings

The aim of this study was to employ the Analytic Network Process (ANP) technique with strong scientific support to address the issue of weighting evaluation performance indicators with a Balanced Scorecard approach, in order to achieve a better performance assessment by determining the share and priority of each indicator and considering the impact of quantitative values. As mentioned, the questionnaires were examined for validity and reliability, and the quantitative values of the target and performance of the measurement indicators were investigated as primary data.

The results of this research indicate that, from the perspective of company officials and experts, the financial and customer perspectives hold greater importance among the other perspectives of the Balanced Scorecard. This could be a promising sign of progress towards the company's mission of providing sustainable and economically efficient electricity distribution for the development and well-being of society. The results also indicate that the internal process and learning and growth perspectives are considered less important by the company, ensuring they do not neglect human and organizational resources due to resource limitations. Regarding the overall priority of the indicators, it was determined that the average duration of outages per subscriber, claims collection period, and average waiting time for power supply by the company are of highest importance, while the number of incident-prone points resolved, average time to install measurement equipment, percentage of testing and inspection of subscriber measurement equipment, and percentage of digital meters available are of least importance in evaluating the company's performance. Additionally, the role of other indicators in the assessment is considered average.

The final performance score of the regional electricity distribution company shows that the company had good performance in regions two, three, and seven, average performance in regions one and five, and poor performance in regions six and four.

Conclusion

The Balanced Scorecard model, when implemented with a strategy execution perspective, can be a supportive tool for management systems in the electricity industry. Combining it with multi-criteria decision-making methods such as ANP not only addresses the issue of weighting evaluation performance indicators but also resolves the problem of not considering the interdependencies between components at the same level and the existence of recursive relationships. The final performance scores of regions and the identification of weak regions can assist managers in finding solutions to enhance their performance and can also be useful in evaluating managers and experts in distribution regions. We hope that paying attention to the obtained results and reconsidering the priority of indicators in achieving objectives through programs and strategies will lead to an improvement in company planning and productivity. This research was conducted using the Analytic Network Process and empirical data, and the use of other multi-criteria decision-making methods such as DEMATEL, which complements ANP, and combining them with fuzzy theory for ranking and evaluating performance, can provide even more realistic results.

Table 2. Regional Performance Final Scores

Region	Final Performance Score
Two	86.04
Three	84.80
Seven	83.89
One	81.95
Five	80.82
Six	77.81
Four	70.79

Conflict of interest:
None.
Financial support:
None.
Ethics statement:
None.

References

1. Asadi, Mir Mohammad et al. (2010). "Performance Evaluation of Government Hospitals in Yazd Province Using a Combination of Balanced Scorecard Models, Data Envelopment Analysis, and SERVQUAL." Shahid Sadoughi University of Medical Sciences Research Journal, No. 6, 559-569.

2. Eshlaghi, Abbas (2010). "Presenting a Dynamic Model for Simulating Balanced Scorecard to Achieve Effective Strategies (Case Study: Mahan Airline Company)." Management Accounting Journal, No. 6, 89-104.
3. Irvani Tabrizi Pour, Amir Pouya et al. (2011). "Application of Combined FAHP-BSC Approach for Performance Evaluation of Hashemi Nejad Hospital, Tehran." Health Information Management Journal, No. 3, 327-337.
4. Zobrdast, Esfandiar (2010). "Application of Network Analysis Process in Urban and Regional Planning." Fine Arts Journal, No. 41, 79-90.
5. Shafiei, Morteza (2014). "Performance Evaluation of the Supply Chain Using Data Envelopment Analysis and Balanced Scorecard Approach." Journal of Applied Mathematical Modeling, No. 3, 23-33.
6. Aidemark, L.G., Baraldi, S., Funck, E.K.& Jansson, A.(2010). The importance of balanced scorecards in hospitals. *Managerial and Financial Accounting* ,20, 85-363.
7. Carlucci, D. & Schiuma, G. (2008), Applying the analytic network process to disclose knowledge assets valuecreation dynamics. *Journal of Expert Systems with Applications*, 36(4), 7687-7694.
8. Jharkharia, S., Shankar, R. (2007), Selection of logistics service provider: An analytic network process (ANP). *Journal of Omega*, 35(3), 274-289.
9. .Kaplan ,R.S., Norton ,D.P. The Balanced Scorecard: converting strategy into action. Translator: Melmasi ,R., Seyfi, M.(2007).Tehran. business publish.
10. Kaplan ,R.S., Norton ,D.P.(1992).The Balanced Scorecard—Measures that Drive Performance, *Journal of Harvard Business Review*,92(105),71-78.
11 . Lee, H. et al. (2009). Selection of technology acquisition mode using the analytic network process, *Journal of Mathematical and Computer Modeling*, 49,1274-1282.
12. Li Yan-Lai.(2012). Determining the final priority ratings of customer requirements in product planning by MDBM and BSC. . *Journal of Expert Systems with Applications*,39(1), 1243-1255.
13 .Martinsons ,M , Davison R , Tse D . (1999). The balanced scorecard: a foundation for the strategic management of information systems. *Journal of Decision Support System.*
14. Saaty, T. L. (1999), Fundamentals of the Analytic Network Process. *Journal of Japan Kobe.*
15. Tjader ,Y, H.Maya ,J.(2013). Firm-level outsourcing decision making: A balanced scorecard-based analytic network process model. *Journal of Production economics*,04(017).
16.Tuan, T.T. (2020), "The impact of balanced scorecard on performance: the case of Vietnamese commercial banks", The Journal of Asian Finance, Economics, and Business, Vol. 7 No. 1, pp. 71-79.
17. Rehman, S.-U., Kraus, S., Shah, S.A., Khanin, D. and Mahto, R.V. (2021a), "Analyzing the relationship between green innovation and environmental performance in large manufacturing firms", Technological Forecasting and Social Change, Vol. 163, p. 120481.
18. . Pham CD, Vu ST, Pham YT, Vu NT. Evaluating the performance of Vietnamese public hospitals based on balanced scorecard. J Asian Finance Econ Bus. 2020;7(6):339–49. https://doi.org/10.13106/jafeb.2020.vol7.no6.339.
19. . Jahanian A, Hamidian M, Khosravipour N, Azizi H. The gap between current and desired performance evaluation system of balanced scorecard in specialty and subspecialty Tehran's Milad hospital. J Econ Stud fnan Mange Account. 2017;3(2):102–13.