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An Application of Data Envelopment Analysis and Game Theory for Appraisal of Balanced Scorecard Indexes in Media Industry

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ABSTRACT

Todays, the media industry encompasses all businesses that allow information to be shared (traditional and digital media). Media is vast, large, and ever-growing, and is an incredibly popular sector at the minute, and an extremely interesting area to research work in. This paper considered a news agency of media organization as a Decision-Making Unit (DMU). The aim of the study was to evaluate the role of Balanced Scorecard (BSC) indexes on measuring the efficiency of DMU. This was done by a new hybrid model of Data Envelopment Analysis (DEA), cooperative game theory and Shapley value index. The initial values of the DEA model were selected from among the BSC indexes in four perspectives (i.e., financial, customer, internal processes, and growth and learning). Finally, the proposed model was experimented on a case study and the computational results were obtained. The results showed that the profitability ratio with a Shapley value of 2.903 and the percentage of satisfied audiences with a Shapley value of 0.404 had the highest and lowest reflection in performance assessment, respectively. The rest of the results were presented and discussed in detail. This study can reveal scientific orientation to increase organizational performance to media managers and policymakers.

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INTRODUCTION

Assessing the organizational performance is a feedback system that determines the organization's strengths and weaknesses, the degree of efficiency of operational units and the degree of effectiveness, and achievement of the goals and plans of each organization [1, 2]. In fact, the topic of performance assessment is one of the broad topics that have been influenced by a wide range of disciplines and experts, and many models and frameworks have been presented in this field. Measuring efficiency index is one of the ideas that has been used in extensive studies to reflect performance. This issue has been widely criticized in recent years and many researchers have presented various scientific and practical methods to overcome the various challenges of assessing the organization's performance [3, 4].

Balanced Scorecard (BSC) and Data Envelopment Analysis (DEA) are among the models that researchers have presented in order to assessing the organization's performance, and each of them has received criticism despite its many advantages. According to the critics of the BSC model, despite all the undeniable advantages, this model also faces some shortcomings. BSC indexes that form the organization's strategy map are usually used in meetings of senior managers to measure the degree of achievement of strategic goals. Monitoring and verifying these indexes are a challenge that managers have always sought to solve. Over time, this challenge has become a fundamental weakness in BSC, and it can be seen that between 50 and 70 percent of BSC projects are incompletely implemented due to the lack of calculation of key performance indicators and could not guarantee the effectiveness of the organization. The question that has always focused the minds of senior managers of an organization is how to measure the BSC indexes so that in addition to guaranteeing the effectiveness of the organization's goals, they play a high role in the organization's efficiency? This question indicates that the analysis based on BSC cannot determine the inefficiency of using resources [5].

In parallel with these problems, there have been some challenges in DEA models that researchers have answered. For example, see [6] and [7]. One of these challenges has been determining the importance of input and output variables in DEA models. After selecting the input and output variables of Decision-Making Units (DMUs), decision makers are usually faced with the problem of how to measure the importance of these variables in determining the efficiency of the organization. Li and Liang [8] responded to this challenge by focusing on the cooperative game theory and determined the importance of variables in measuring the efficiency score of the organization. They showed that game theory is highly effective in determining the importance of initial DEA values and can be an idea for future studies.

Based on the mentioned background, the following questions are raised:

- Which BSC indexes can be used to reflect organizational performance?
- How to obtain the impact of BSC indexes on DEA efficiency scores?
- How does game theory contribute to the ranking of DEA variables?
- The presented methodology will be tested on the case study of which industry?
- Are the results of this research applicable in different industries?

We have presented a two-stage methodology with the aim of answering the main questions raised. In the first stage, a combined model of BSC-DEA is presented. In the second stage, by using the combined model of cooperative game theory and DEA [8], the ranking of the effectiveness of these indexes in determining the efficiency score of the organization is done. The integrated model proposed in this paper can rank the BSC indexes according to the degree of effectiveness in measuring the efficiency of the organization. It also provides the opportunity for senior managers to identify vital indicators in measuring the efficiency of the organization from various dimensions.

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The necessity of research becomes more obvious when we know that the presented methodology is implemented in one of the media industry organizations. This research in the second stage (by concretizing the tool presented in the first stage) solves one of the main problems of the media, which is "identifying effective indicators and improving them". The media industry includes all the organizations that store and share information with consumers using communication methods and tools. These organizations share this information in various ways, including television, radio, social media, newspapers, films, video games and music. According to these definitions, todays the media sector is growing strongly and plays an important role in the economy and business around the world. Therefore, it is necessary for the studies of researchers and scientists to grow and develop in this field. Obviously, this will help increase the performance of media organizations. This is exactly the problem that this paper focuses on.

During the last two decades, several authors have focused their attention on the combination of DEA and BSC methods in order to evaluate performance. For example, Chiang and Lin [9] introduced a DEA model with four inputs and four outputs (based on BSC perspectives) to evaluate the performance of automobile companies and commercial banks. Asosheh et al., [10] evaluated information technology (IT) projects by presenting the combined DEA-BSC method. First, they proposed a combination of two management methods, i.e., BSC and DEA, with the aim of creating a new method for selecting IT projects. Then they introduced a new integrated model of DEA to identify more efficient IT projects according to ordinal and cardinal data. The mentioned researches [9, 10] show how BSC concepts can be combined with DEA method to achieve holistic models.

In the field of combining the two methods of game theory and DEA, a few but useful researches have been done. Nakabayashi et al., [11] investigated the combination of game theory and DEA in research entitled “Egoist’s dilemma: a DEA game”, which was relatively comprehensive research at the National Institute of University Education in Japan. They addressed the problems of building consensus among individuals or organizations that had different criteria for evaluating their performance. In fact, they suggested that when players are expected to be selfish, what solution should be offered? In the problem they considered, each DMU relied on its superiority in the criteria in which it was more successful. These researchers investigated and analyzed this situation within the framework or concept created in DEA. This problem led to a choice dilemma which is called “Selfish Man’s Enigma” and this choice dilemma was investigated using “Cooperative Game Theory” and a solution was proposed for it. The result adopted in this study could be used to achieve appropriate cost allocations as well as cost-benefit distributions. Jie et al., [12] presented a new method using game theory to determine the cross-efficiency of DMUs in DEA. They introduced the cross-efficiency evaluation method and analyzed the existing problems when using the final average cross-efficiency to evaluate DMUs and rejected the average cross-efficiency hypothesis, as well as combining the theory of cooperative games (assuming that DMUs are the players of this game). Then, defined a cooperative game that includes all DMUs and the value of the characteristic functions of all cooperatives. Based on the analysis of the solutions of this collaborative game, they chose the kernel as the final solution and used the genetic algorithm to obtain the kernel and the final weight of each DMU. But Li and Liang [8] conducted research that is the basis of the decision regarding the valuation of BSC indicators in current paper. They determined the importance of the input and output variables of DEA with the tool of cooperative game theory, which will be examined in detail in the next section.

After a relatively comprehensive review of the literature on the subject and especially the review of the research conducted in the integrated approaches [5, 8-12], it should be said that until now there have been no studies on determining the importance of BSC indicators by the combined technique of DEA and game theory. Therefore, the contribution of this paper in presenting a proposed model for prioritizing the effectiveness of BSC indicators in measuring the organization’s efficiency using the combined approach of DEA and game theory is considerable.

RESEARCH METHODS

1. Model presentation based on case study

The main research model is presented in three steps: "Determining BSC function indicators", "DEA modeling using BSC indicators" and "Determining the importance of BSC indicators using the combined approach of DEA and Game Theory". The first step, which is related to the determination of BSC indicators of the organization, is done by converting the soft and qualitative indicators of the media into quantitative and measurable indicators. In the second step, the combination of BSC and DEA techniques makes it possible to evaluate the efficiency of the organization using the effectiveness indicators derived from the balanced scorecard. Finally, in the third step, the extracted indicators are ranked using the combined technique of DEA and Game Theory.

Regarding the studied organization, it should be said that this organization is a media organization and more precisely, a news agency (at the discretion of the management of this news agency, the name of this media is not mentioned in the paper). This news agency was established in 2010 with the aim of presenting the news and events of Iran and the world in a concise, short and fast way. In this regard, it uses various communication platforms such as the social media, website, and e-mail. Using leading technologies in the media industry, this media has presented a new model in the field of domestic and international news agencies. Due to the nature of its work and its mission, this news agency is an agile and flexible media and has put comprehensiveness, speed and accuracy in its goals.

2. BSC indicators

Performance indicators are actually the heart of the balanced evaluation method. These indicators are tools that are used to ensure the achievement of goals and move towards the successful implementation of the strategy. BSC indicators in this article were determined after reviewing the strategic documents of the studied organization and interviewing senior managers in four perspectives as described in Table 1 [5]:

Table 1. BSC indicators of the media organization (Digital news agency in Iran)

Perspective	**Financial**	**Customer**	**Internal processes**	**Growth and Learning**
Indicator	1. Profitability Ratio	2. Size of Audience 3. Satisfied Audience Percentage	4. Velocity of Propagation 5. Accuracy in Production	6. Human Resources Satisfaction Rate

3. DEA modeling using the BSC indicators

In this part, the decision-making units of this media organization are defined. DMUs can be several organizations with similar performance (homogeneous inputs and outputs) or one organization in several consecutive periods. In this research, the performance of news agency is evaluated in several similar periods of two months during the three years of 2010, 2011 and 2012 according to Table 2.

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Table 2. Definition of organization' DMUs

Year	DMUs	Period
2010	DMU 1	The fifth two months
	DMU 2	The sixth two months
2011	DMU 3	The first two months
	DMU 4	The second two months
	DMU 5	The third two months
	DMU 6	The fourth two months
	DMU 7	The fifth two months
	DMU 8	The sixth two months
2012	DMU 9	The first two months
	DMU 10	The second two months
	DMU 11	The third two months
	DMU 12	The fourth two months
	DMU 13	The fifth two months
	DMU 14	The sixth two months

As you can see, DMUs for this news agency, which is considered a dynamic media, have been considered in the form of two-month periods. The reason for considering short periods is the complex nature of the media, in which the need for quick management decisions is felt in order to adapt to the changes in the turbulent environment of this industry.

Parallel to the definition of DMUs of the organization, the allocation of BSC indicators as output variables of DMUs is considered. The combined BSC-DEA model considers the periodical costs of the organization in order to reach the goals of BSC indicators as inputs of DMUs and indicators in each aspect of BSC as outputs of DMUs. Figure 1 shows the conceptual model presented in this research.

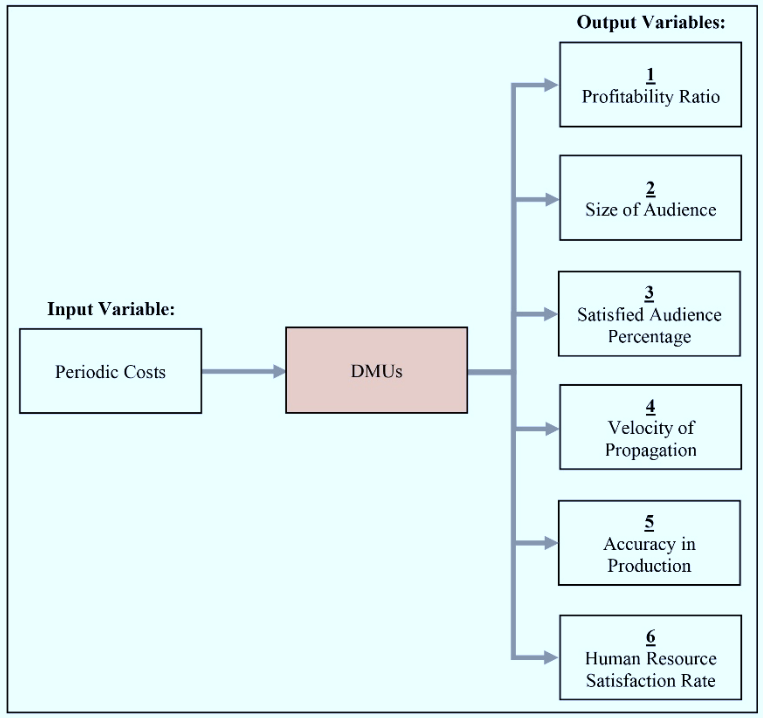

Fig. 1. A view of the organization's DMUs with inputs-outputs

In fact, this paper determined the input and output of DMUs by relying on previous studies and looking at the combined BSC-DEA models [13]. In order to quantify the inputs and outputs of DMUs, the indicators formula was given to an experienced group that was responsible for recording all the information of the organization and its two-year performance in this media. The values presented by this group are presented in Table 3.

Table 3. Input-output values of DMUs

	Input	Output					
DMUs	**Periodic Costs**	**Profitability Ratio**	**Size of Audience**	**Satisfied Audience Percentage**	**Velocity of Propagation**	**Accuracy in Production**	**Human Resources Satisfaction Rate**
1	120	10%	200	60%	67%	80%	70%
2	180	12.5%	220	53%	75%	74%	83%
3	105	8.5%	180	75%	90%	70%	66%
4	150	15%	235	67%	73%	90%	74%
5	190	20%	250	60%	80%	81%	60%
6	175	17.5%	235	58%	78%	65%	69%
7	186	15.6%	300	80%	81%	76%	70%
8	190	13%	280	66%	72%	83%	80%
9	200	22.5%	277	70%	85%	87%	70%
10	203	21.5%	300	67%	75%	91%	85%
11	210	20%	287	71%	65%	84%	81%
12	220	25%	296	85%	75%	60%	73%
13	205	23%	310	81%	70%	70%	90%
14	230	17.5%	301	77%	75%	89%	87%

4. Shapley value index to determine the importance of variables in DEA

Game theory is divided into two main branches: non-cooperative games and cooperative games. In the cooperative games used in this paper, the players have the possibility to cooperate and share efforts, and the main goal of these games is to provide a method for the fair distribution of the profits from cooperation. An *n*-player cooperative game is in the form of the characteristic function of an ordered pair $G(N, V)$, where N is a finite set with n members ($N = \{1, 2, \ldots, n\}$). In fact, N is the set of actors and V is a real value that shows the utility value of the coalition actors. The main questions in the model of cooperative games are two: What coalitions are formed? And if a coalition is formed, how will the actors divide the profit or cost? In order to answer these two questions and a fair division for the profit obtained from cooperation, Shapley value index is proposed, which will be studied further on how to use this index and its use in determining the importance of DEA variables [8, 12].

In order to present the model for determining the importance of variables, first n independent DMUs are considered, where each DMU_j ($j = 1, 2, \ldots, n$) contains m input $[x_{ij}\ (i \in M = \{1, 2, \ldots, m\})]$ and s output $[y_{rj}\ (r \in S = \{1, 2, \ldots, s\})]$.

The efficiency of each DMU_d with the CCR input-oriented standard is obtained from Equation 1 [14]:

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$$\begin{aligned} & E_d(M, S) = Min\ \theta \\ & Subject\ to: \\ & \sum_{j \in N} \lambda_j x_{ij} \le \theta x_{id}, \quad i \in M \\ & \sum_{j \in N} \lambda_j y_{rj} \le y_{rd}, \quad r \in S \\ & \lambda_j \ge 0, \forall d, j \in N, \theta: free \end{aligned} \quad (1)$$

In Equation 1, $E_d(M, S)$ is the efficiency of DMU_d considering the input data of the M set and the output data of the S set. Without detracting from the generality of the problem, the method of calculating the importance of one of the input variables is examined [14, 15].

Definition 1: *ECR* of input variable x_i in DMU_d is defined as follows [8]:

$$ECR_d^s = \frac{E_d(M,S)}{E_d\left(M / \{i\}, S\right)} - 1, d \in N; \forall \{i\} \subset M, \{i\} \ne M \quad (2)$$

In Equation 2, $E_d(M / \{i\}, S)$ is the efficiency score of DMU_d based on Equation 1 with input set $M/\{i\}$ and output set S.

Definition 2: *ECR* of the *P* set of *M* input variables is defined as Equation 3 [8]:

$$ECR_d^s(P) = \frac{E_d(M,S)}{E_d\left(M / P, S\right)} - 1, d \in N; \forall P \subset M, P \ne M \quad (3)$$

Definition 3: For the coalition *P* from the set of input variables *M*, V_P^S for all DMUs is defined as Equation 4 [8]:

$$V_P^S = \sum_{d=1}^{n} ECR_d^s(P) \quad (4)$$

As can be seen, V_P^S is a characteristic function for *P* coalition. Therefore, there is a coalition game *(M, V)*. As mentioned, Shapley value is used as a cooperative game solution *(M, V)*. Therefore, the importance of each input variable can be obtained with Equation 5:

$$\varphi_i^S(V) = \sum_{\substack{i \in P \\ P \subset M, P \ne M}} \frac{(p-1)!(m-p)!}{m!} \left[V^S(P) - V^S(P / \{i\}) \right] \quad (5)$$

In Equation 5, *p* is the number of members of coalition *P* and *m* is the number of entries in set *M*. Since the Shapley value is unique for each cooperative game, the degree of importance of each input or output variable obtained through the Shapley value is unique.

Although Equation 5 is to evaluate the importance of each input variable, the proposed method can be written as Equation 6 to determine the importance of each output variable:

$$\varphi_r^M(V) = \sum_{\substack{r \in Q \\ Q \subseteq S, Q \neq S}} \frac{(q-1)!(s-q)!}{s!} \left[V^M(P) - V^M(Q/\{r\}) \right] \quad (6)$$

Where, $Q \subset N$ is a coalition of N and q is the number of members of the coalition Q and s is the number of outputs of S.

RESULTS AND DISCUSSION

1. Using of DEA and game theory for appraisal of BSC indicators

In this step, after presenting the following algorithm, the importance of the BSC function indicators in measuring the efficiency of the organization is calculated:

Step 1. First, a candidate variable Y_r is considered as the first player, and then all subsets (coalitions) of Q including Y_r from S are listed. As an example, all the coalitions of the first variable are given in Table 4:

Table 4. Q coalitions with q number of members including variable (player) Y_1

		$Q \subset S, Q \neq S$		
q = 1	**q = 2**	**q = 3**	**q = 4**	**q = 5**
{1}	{1,2}	{1,2,3}	{1,2,3,4}	{1,2,3,4,5}
	{1,3}	{1,2,4}	{1,2,3,5}	{1,2,3,4,6}
	{1,4}	{1,2,5}	{1,2,3,6}	{1,2,3,5,6}
	{1,5}	{1,2,6}	{1,2,4,5}	{1,2,4,5,6}
	{1,6}	{1,3,4}	{1,2,4,6}	{1,3,4,5,6}
		{1,3,5}	{1,2,5,6}	
		{1,3,6}	{1,3,4,5}	
		{1,4,5}	{1,3,4,6}	
		{1,4,6}	{1,3,5,6}	
		{1,5,6}	{1,4,5,6}	

Step 2. Model (Equation) 1 is solved three times and the values of $E_j(M, S)$, $E_j(M, S/Q)$ and $E_j(M, S/(Q/\{r\}))$, $j \in N$ are calculated.

Step 3. According to Definition 2 values of $ECR_j^M(Q)$ and $ECR_j^M(Q/\{r\})$, $j \in N$ is calculated (For example, in Table 5, the values of steps 2 and 3 of current algorithm are given for some coalitions of the first variable).

Step 4. Based on Definition 3, the values of $V^M(Q)$ and also $V^M(Q/\{r\})$, $\forall Q \subset S$ are determined (As an example, Table 6 shows the values of this step of the algorithm for the first variable coalitions).

Step 5. Using Equation 6, the Shapley values and the importance of Y_r variable in determining efficiency are calculated.

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After executing the algorithm mentioned above for each DEA output variable, the Shapley value or in other words the ranking of the effect of each BSC index on the organization's efficiency score was obtained as described in Table 7.

Table 5. The values of ECR_j^M and E_j obtained from the coalitions of players with the first player

		DMU_j													
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
	E_j (M, S)	1.00	0.79	1.00	1.00	0.95	0.94	0.96	0.86	1.00	0.98	0.89	1.00	1.00	0.81
Q = {1, 2}	**Ej (M, S/Q)**	1.00	0.73	1.00	0.90	0.64	0.63	0.61	0.67	0.65	0.67	0.61	0.54	0.70	0.60
	ECR_j^M (Q)	0.00	0.07	0.00	0.11	0.01	0.49	0.57	0.28	0.53	0.46	0.45	0.85	0.43	0.34
	E_j (M, S/(Q/{r}))	1.00	0.79	1.00	1.00	0.95	0.94	0.84	0.75	1.00	0.98	0.88	1.00	1.00	0.76
	ECR_j^M (Q/{r})	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.15	0.00	0.00	0.01	0.00	0.00	0.07
Q = {1, 3}	**Ej (M, S/Q)**	1.00	0.73	1.00	0.91	0.77	0.78	0.94	0.86	0.81	0.86	0.80	0.76	0.88	0.76
	ECR_j^M (Q)	0.00	0.07	0.00	0.09	0.24	0.19	0.02	0.00	0.24	0.14	0.12	0.32	0.13	0.06
	E_j (M, S/(Q/{r}))	1.00	0.79	1.00	1.00	0.95	0.94	0.96	0.86	1.00	0.98	0.89	1.00	1.00	0.81
	ECR_j^M (Q/{r})	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Q = {1, 4}	**Ej (M, S/Q)**	1.00	0.73	1.00	0.91	0.77	0.78	0.94	0.86	0.81	0.86	0.80	0.76	0.88	0.76
	ECR_j^M (Q)	0.00	0.07	0.00	0.09	0.24	0.19	0.02	0.00	0.24	0.14	0.12	0.32	0.13	0.06
	E_j (M, S/(Q/{r}))	1.00	0.79	1.00	1.00	0.95	0.91	0.96	0.86	1.00	0.98	0.89	1.00	1.00	0.81
	ECR_j^M (Q/{r})	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Q = {1, 5}	**Ej (M, S/Q)**	0.97	0.73	1.00	0.91	0.77	0.78	0.94	0.86	0.81	0.86	0.80	0.76	0.88	0.76
	ECR_j^M (Q)	0.03	0.07	0.00	0.09	0.24	0.19	0.02	0.00	0.24	0.14	0.12	0.32	0.13	0.06
	E_j (M, S/(Q/{r}))	0.99	0.79	1.00	0.99	0.95	0.94	0.96	0.86	1.00	0.97	0.89	1.00	1.00	0.81
	ECR_j^M (Q/{r})	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.00	0.00	0.00
Q = {1, 6}	**Ej (M, S/Q)**	1.00	0.71	1.00	0.91	0.77	0.78	0.94	0.86	0.81	0.86	0.80	0.76	0.88	0.76
	ECR_j^M (Q)	0.00	0.11	0.00	0.09	0.24	0.19	0.02	0.00	0.24	0.14	0.12	0.32	0.13	0.06
	E_j (M, S/(Q/{r}))	1.00	0.75	1.00	1.00	0.95	0.94	0.96	0.86	1.00	0.98	0.89	1.00	1.00	0.81
	ECR_j^M (Q/{r})	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Q = {1, 2, 3}	**Ej (M, S/Q)**	1.00	0.73	1.00	0.90	0.64	0.63	0.61	0.67	0.65	0.67	0.61	0.53	0.70	0.60
	ECR_j^M (Q)	0.00	0.07	0.00	0.11	0.01	0.49	0.57	0.28	0.53	0.46	0.45	0.89	0.43	0.34
	E_j (M, S/(Q/{r}))	1.00	0.79	1.00	1.00	0.95	0.94	0.82	0.75	1.00	0.98	0.88	1.00	1.00	0.76
	ECR_j^M (Q/{r})	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.15	0.00	0.00	0.01	0.00	0.00	0.07
Q = {1, 2, 4}	**Ej (M, S/Q)**	1.00	0.73	1.00	0.90	0.64	0.63	0.61	0.67	0.65	0.67	0.61	0.54	0.70	0.60
	ECR_j^M (Q)	0.00	0.07	0.00	0.11	0.01	0.49	0.57	0.28	0.53	0.46	0.45	0.85	0.43	0.34
	E_j (M, S/(Q/{r}))	1.00	0.79	1.00	1.00	0.95	0.91	0.84	0.75	1.00	0.98	0.88	1.00	1.00	0.76
	ECR_j^M (Q/{r})	0.00	0.00	0.00	0.00	0.00	0.03	0.15	0.15	0.00	0.00	0.01	0.00	0.00	0.07
Q = {1, 2, 5}	**Ej (M, S/Q)**	0.93	0.73	1.00	0.79	0.50	0.63	0.60	0.67	0.56	0.67	0.61	0.54	0.70	0.60
	ECR_j^M (Q)	0.08	0.07	0.00	0.27	0.89	0.49	0.60	0.28	0.73	0.47	0.45	0.85	0.43	0.34
	E_j (M, S/(Q/{r}))	0.97	0.79	1.00	0.98	0.95	0.94	0.83	0.75	1.00	0.96	0.86	1.00	1.00	0.75
	ECR_j^M (Q/{r})	0.03	0.00	0.00	0.02	0.00	0.00	0.16	0.15	0.00	0.02	0.03	0.00	0.00	0.07
Q = {1, 2, 6}	**Ej (M, S/Q)**	1.00	0.62	1.00	0.90	0.64	0.56	0.61	0.66	0.65	0.67	0.60	0.54	0.55	0.58
	ECR_j^M (Q)	0.00	0.28	0.00	0.11	0.89	0.68	0.57	0.31	0.53	0.46	0.48	0.85	0.81	0.39
	E_j (M, S/(Q/{r}))	1.00	0.71	1.00	1.00	0.95	0.92	0.84	0.71	1.00	0.96	0.87	1.00	1.00	0.74
	ECR_j^M (Q/{r})	0.00	0.11	0.00	0.00	0.00	0.01	0.15	0.21	0.00	0.02	0.02	0.00	0.00	0.09
Q = {1, 3, 4}	**Ej (M, S/Q)**	1.00	0.73	1.00	0.91	0.77	0.78	0.94	0.86	0.81	0.86	0.80	0.76	0.88	0.76
	ECR_j^M (Q)	0.00	0.07	0.00	0.09	0.24	0.19	0.02	0.00	0.24	0.14	0.12	0.32	0.13	0.06
	E_j (M, S/(Q/{r}))	1.00	0.79	1.00	1.00	0.95	0.91	0.96	0.86	1.00	0.98	0.89	1.00	1.00	0.81
	ECR_j^M (Q/{r})	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 6. Values of V^M *(Q)* and V^M *(Q/{r})* for the first player (variable)

Q	*V (Q)*	*V (Q/{r})*	*V (Q) - V (Q/{r})*
{1,2}	4.601	0.373	4.228
{1,3}	1.618	0	1.618
{1,4}	1.618	0.030	1.588
{1,5}	1.646	0.069	1.577
{1,6}	1.650	0.054	1.596
{1,2,3}	4.646	0.401	4.245
{1,2,4}	4.601	0.403	4.198
{1,2,5}	5.959	0.486	5.076
{1,2,6}	6.358	0.601	5.757
{1,3,4}	1.618	0.030	1.588
{1,3,5}	1.646	0.046	1.600
{1,3,6}	1.650	0.061	1.589
{1,4,5}	1.646	0.115	1.531
{1,4,6}	1.650	0.089	1.561
{1,5,6}	1.637	0.109	1.528
{1,2,3,4}	5.123	0.457	4.666
{1,2,3,5}	6.071	0.510	5.561
{1,2,3,6}	6.698	0.688	6.010
{1,2,4,5}	6.027	0.575	5.452
{1,2,4,6}	6.026	0.673	5.254
{1,2,5,6}	10.146	0.971	9.175
{1,3,4,5}	1.605	0.117	1.488
{1,3,4,6}	1.608	0.090	1.518
{1,3,5,6}	1.637	0.109	1.528
{1,4,5,6}	1.645	0.173	1.472
{1,2,3,4,5}	6.081	0.636	5.445
{1,2,3,4,6}	13.821	0.796	13.025
{1,2,3,5,6}	12.633	1.115	11.518
{1,2,4,5,6}	10.893	1.161	9.732
{1,3,4,5,6}	1.637	0.199	1.438

Table 7. Ranking the effectiveness of BSC indicators in measuring the efficiency of the organization

Indicator	Shapley Value	Rank
Profitability Ratio (Y_1)	2.903	1
Size of Audience (Y_2)	2.362	2
Human Resources Satisfaction Rate (Y_6)	0.813	3
Accuracy in Production (Y_5)	0.628	4
Velocity of Propagation (Y_4)	0.492	5
Satisfied Audience Percentage (Y_3)	0.404	6

2. Computations analysis from organization perspective

This section examines and analyzes the answers provided by the proposed composite model. Based on the final results of Table 7, the BSC indicators can be ranked based on their impact on the organization's efficiency as $Y_1 > Y_2 > Y_6 > Y_5 > Y_4 > Y_3$. As can be seen, the profitability rate with the Shapley value of 2.903 plays the most importance in determining the efficiency of this media organization. This result is very important, because most of Iran's media organizations do not have a documented income generation model for their business and consider income generation as the last option in formulating strategies and determining key performance indicators. The Shapley value of the profitability rate variable indicates that this media organization should think about maintaining its efficiency and survival in the media space of Iran and the world by creating highly innovative plans for revenue generation.

But the second variable with the title of "size of audience" which is actually one of the main prerequisites for generating income and another vital factor in the survival of a media was introduced as a very important index in determining the efficiency of this news agency with a Shapley value of 2.362. The media loses its meaning without an audience, and it is the audience who give it an identity by accepting a medium. On the other hand, the media's revenue generation methods are directly dependent on the audience. In fact, the media in its most routine mode generates income and profitability by producing content for the audience and producing an audience for the advertisers. Therefore, the high number of audiences of a media is the guarantee of the survival of that media in the competitive and complex environment of this industry.

The third variable, i.e., audience satisfaction percentage, obtained the Shapley value of 0.404, the lowest score among the BSC indicators in determining the efficiency of the organization. The reason for this in the interview with the senior managers was that the increase in the number of audiences is actually the result of their satisfaction with the news agency, and the presence of this indicator in the perspective of the BSC customer in the translation of the organization's strategy gets a low score. The managers of the organization came to the conclusion that by removing this index and replacing it with an index that does not overlap with the index of the number of audiences and shows another dimension of the strategy, they can better identify and evaluate the key factors of their success.

In the dimension of internal processes, two indicators of the function "accuracy in production" and "velocity of propagation" by obtaining the Shapley value of 0.628 and 0.492 evoke certain concepts. These results indicate that "accuracy in production" plays a greater role than "velocity of propagation" in the efficiency of the organization; A very important point that many media outlets do not pay attention to and sacrifice accuracy for the velocity of propagation. Iranian media organizations consider the speed of publication as one of the main factors of their efficiency. While the results obtained during this research made us realize that accuracy in production plays a greater role than the velocity of news dissemination in the media space.

The last variable titled "human resources satisfaction rate" with a Shapley value of 0.813 ranks third among other indicators. Therefore, the human resources of this media organization, as the front line of production, distribution and publishing operations, are the main asset of this news agency in creating value for the audience and gaining the efficiency score of the organization. Maximum satisfaction of these resources will be possible by implementing educational, motivational and research programs.

CONCLUSION

In this paper, the study model of BSC indicators' effect on measuring the organization's efficiency was presented using the combined approach of game theory and DEA based on a case study in the media industry. As seen, first, BSC indicators were determined in four perspectives: financial, customer, internal processes, and growth and learning. After this stage, DMUs were considered as 14 periods of 2 months from the end of 2010 to the end of 2012. In the following, BSC indicators were considered as output and costs as input of these units. In the next step, the combined model of DEA and cooperative games theory was presented and used. Finally, the Shapley value of the output variables of DMUs, which were the indicators of the BSC function, were obtained. Based on this values, important decisions were made at the senior management level of the organization, which were discussed in detail in the computational analysis section.

According to the results and findings of this research and the cases that were examined, the development of cause-and-effect relationships within financial, customer, internal processes and growth and learning using BSC indicators can be considered as a suggestion for future researches. Also, using the theory of cooperative games in determining the joint weight of DMUs can be practical research in the field of DEA. In addition, the use of uncertainty tools such as fuzzy, neutrosophic, etc., can increase the compatibility of future researches results with the real world.

REFERENCES

[1] R. Kiani Mavi, A. Makui, S. Fazli, and A. Alinezhad, "A forecasting method in data envelopment analysis with group decision making," *International Journal of Applied Management Science*, vol. 2, no. 2, pp. 152-168, 2010.

[2] H. Fitria, D. H. Widyaningrum, R. Malik, N. I. Safutra, and Y. Herdianzah, "To Optimization Of Chicken Feed Production Using Goal Programming Method At PT. Japfa Comfeed Indonesia Tbk. Unit Makassar," *Journal of Industrial System Engineering and Management*, vol. 1, no. 1, pp. 1-5, 2022.

[3] A. Alinezhad and A. Taherinezhad, "Performance Evaluation of Production Chain using Two-Stage DEA Method (Case Study: Iranian Poultry Industry)," *new economy and trad*, vol. 16, no. 3, pp. 105-130, 2021.

[4] K. Sarrafha, A. Kazemi, and A. Alinezhad, "A multi-objective evolutionary approach for integrated production-distribution planning problem in a supply chain network," *Journal of Optimization in Industrial Engineering*, vol. 7, no. 14, pp. 89-102, 2014.

[5] J. Khalili and A. Alinezhad, "Performance evaluation in green supply chain using BSC, DEA and data mining," *International journal of supply and operations management*, vol. 5, no. 2, pp. 182-191, 2018.

[6] A. Taherinezhad and A. Alinezhad, "Nations performance evaluation during SARS-CoV-2 outbreak handling via data envelopment analysis and machine learning methods," *International Journal of Systems Science: Operations & Logistics*, vol. 10, no. 1, p. 2022243, 2023.

[7] A. Taherinezhad and A. Alinezhad, "COVID-19 Crisis Management: Global Appraisal using Two-Stage DEA and Ensemble Learning Algorithms," *Scientia Iranica*, Article in press, 2022.

[8] Y. Li and L. Liang, "A Shapley value index on the importance of variables in DEA models," *Expert systems with Applications*, vol. 37, no. 9, pp. 6287-6292, 2010.

[9] C.-Y. Chiang and B. Lin, "An integration of balanced scorecards and data envelopment analysis for firm's benchmarking management," *Total quality management*, vol. 20, no. 11, pp. 1153-1172, 2009

[10] A. Asosheh, S. Nalchigar, and M. Jamporazmey, "Information technology project evaluation: An integrated data envelopment analysis and balanced scorecard approach," *Expert systems with*

applications, vol. 37, no. 8, pp. 5931-5938, 2010.

[11] K. Nakabayashi and K. Tone, "Egoist's dilemma: a DEA game," *Omega*, vol. 34, no. 2, pp. 135-148, 2006.

[12] W. Jie, L. Liang, and Y.-c. ZHA, "Determination of the weights of ultimate cross efficiency based on the solution of nucleolus in cooperative game," *Systems Engineering-Theory & Practice,* vol. 28, no. 5, pp. 92-97, 2008.

[13] C. A. Amado, S. P. Santos, and P. M. Marques, "Integrating the Data Envelopment Analysis and the Balanced Scorecard approaches for enhanced performance assessment," *Omega*, vol. 40, no. 3, pp. 390-403, 2012.

[14] A. Charnes, W. W. Cooper, and E. Rhodes, "Measuring the efficiency of decision making units," *European journal of operational research,* vol. 2, no. 6, pp. 429-444, 1978.

[15] R. D. Banker, A. Charnes, and W. W. Cooper, "Some models for estimating technical and scale inefficiencies in data envelopment analysis," *Management science,* vol. 30, no. 9, pp. 1078-1092, 1984.