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Research Article

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Selection and Assessment of Outsourcing Service Suppliers in Hospitals by Multi-criteria Decision Making and Balanced Scorecard Combined Model

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Abstract

Background and Objectives: Selection and evaluation of suppliers is one of the main steps in the coordination and integration of outsourcing service supply chain. Hospitals outsource many of their services to private companies but so far, the issue of this problem has not been investigated by a systematic and scientific method. Thus, in this study, this problem was investigated by multi-criteria decision making (MCDM) model with fuzzy analytic hierarchical process (FAHP)-FTOPSIS approach and balanced scorecard (BSC).

Methods: This quantitative study was carried out from June to March 2018 in one of the teaching-clinical hospitals in Tehran city (Iran). The supplier selection problem was the MCDM problem, Therefore, AHP-TOPSIS and BSC combined model were proposed and used to select and evaluate the suppliers. Evaluation criteria were weighted using FAHP that was formulated in excel software. Then, based on the weights obtained for the criteria and using the fuzzy TOPSIS technique, we prioritized the suppliers for food service using a survey consisting of 10 officials and experts in the hospital.

Findings: Based on the results, customer and financial aspects of BSC weighted 0.358788 and 0.356949 respectively and had the highest priority in experts' points of view. Among the criteria speed of customer responsiveness (0.108816), the reputation of supplier (0.107017), financial stability (0.098633) and On-time delivery (0.090774) had the highest priorities, respectively. Reliability (0.005542), fame and credit of the supplier (0.005575) repair time (0.005951) and past performance (0.005951) criteria had the lowest priorities. Then three of suppliers were prioritized through fuzzy TOPSIS.

Conclusions: The combination of a BSC model and MCDM approaches provide powerful tools for evaluating and selecting suppliers in the supply chain.

Keywords: Suppliers, Selection, Evaluation, Multi-Criteria Decision Making, Fuzzy Analytic Hierarchy Process, Fuzzy TOPSIS, Balanced Score Card (BSC), Outsourcing, Hospital services

Background and Objectives

Through supply chain the purchase-related decisions have become a critical issue for modern organizations fairly dependent on the suppliers. This is very well known that the direct and indirect consequences of poor decision making are devastating.[1] In fact, the choice of an appropriate set of suppliers to work with for the success of an organization is very critical emphasized over the years.[2] A proper supplier selection inevitably increases the competitiveness of a supply chain.[3] In recent years hospitals have had therapeutic paraclinical and support services outsourced in coordination and integration of their core mission. Therefore, defining selection and evaluation criteria are important steps to be taken.

Studies on the Application of Balanced Scorecard

Many researchers have used a balanced scorecard (BSC) to evaluate suppliers in the health field. Ghotbuee et al, used the combination of a scorecard and a data envelopment analysis (DEA) to evaluate medical centers in Semnan.[4] Hemati and colleagues used a combined approach of BSC and DEMATEL to evaluate Islamic Azad University units.[5] Various authors have used a combination of BSC and MCDM approaches for evaluation and selection of suppliers.[6-15]

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Application of FAHP in Selection and Evaluation of Suppliers

Researchers have provided valuable techniques and approaches to MCDM for supplier selection in the supply chain including analytical hierarchy process (AHP), TOPSIS, data envelopment analysis (DEA), analytical network process, ELECTRE, fuzzy approaches, PROMRTHEE, Artificial Neural Network approaches, etc. Akarte et al defined 18 criteria and 6 objective and 20 subjective goals for supplier evaluation and classified them into four categories: qualitative capabilities, product development capabilities and production, cost and delivery capabilities. They developed a web-based system to evaluate suppliers.[16] Muralidharan et al developed a 5-step AHP model with 9 criteria to rank and evaluate the suppliers.[17] Chan[18] developed a selection model using the AHP to facilitate supplier selection. Chan and Chan used the AHP for the selection and evaluation of suppliers; their model included 6 criteria and 20 sub-criteria. The relative importance rating calculations were done based on customer demands.[19] Liu and Hai[20] used an approach similar to Chan and Chan. This model helps the managers to select and weight the selection criteria. Chan et al[21] proposed AHP based multi-criteria decision approach to select and evaluate suppliers based on 14 criteria. Hou and Su[22] developed a distribution system to identify the proper suppliers for exclusive environment. They used a strong and dynamic approach to assess the product market position and product development.

Chan and Chan proposed an AHP based model to solve the problem of evaluating and selecting suppliers in the fashion industry. The researchers classified the selection and evaluation criteria into performance and company's strategy-based criteria. A total of twenty-nine criteria were identified for selection and evaluation.[23] Kumar and Roy proposed a role-based model with AHP to help the decision-makers in the selection and evaluation of power transmission industry suppliers. In this study, researchers proposed a three-step model for calculating the sellers' performance score and choosing the best seller.[24] Benyoucef and Canbolat applied the fuzzy AHP to select and evaluate hospital's online purchases' suppliers.[25] Karsak and Dursun used fuzzy multi-criteria decision making (MCDM) approach for the selection and evaluation of suppliers in hospital service suppliers in Istanbul.[26] Rahiminezhad Galankashi et al proposed an integrated BSC–fuzzy analytic hierarchical process (FAHP) model to select suppliers in the automotive industry.[27]

Application of Fuzzy TOPSIS in Selection and Evaluation of Suppliers

Few studies are conducted on application of TOPSIS and fuzzy TOPSIS for selection and evaluation of suppliers including the following examples: Zouggari and Benyocef[28] proposed the fuzzy TOPSIS approach based on simulation to select and evaluate suppliers; they classified the evaluation criteria as: 1) performance strategy, 2) service quality, 3) innovations and 4) risk. Esmailian and Rabieh[29] proposed an approach based on fuzzy TOPSIS and fractional planning to select and rank suppliers. Beikkhakhian et al[30] rated 6 suppliers using fuzzy TOPSIS method. Dos Santos et al[31] proposed a method for the evaluation and selection of green suppliers for the Brazilian furniture industry. They used Fuzzy TOPSISS for supplier evaluation.

Methods

The research steps and outputs of each step are presented in Figure 1.

STEP 1: Defining the Criteria Selection, Evaluation and Their Adaptation With the BSC

The requisite of appropriate supplier selection is the suppliers' performance evaluation, which must be done by employing criteria in keeping with the strategic objectives and can provide the manager with a thorough and comprehensive image of the supplier's performance. For identification of appropriate criteria, initially the performed studies in the domain of evaluation and selection of the supplier were considered. In these studies, numerous criteria have been introduced by different researchers (Table 1) most of which are not particularly in line with the hospital services supply chain. Also, their large number

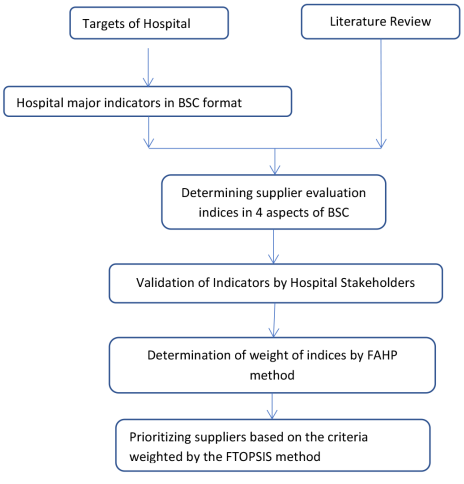

Figure 1. Research conceptual framework (stages of research and output of each step)

Table 1. The Financial Aspect Criteria for Selection and Evaluation of the Suppliers' Performance

Code	Criteria	Explanations	Strategic Objectives of the Hospital
FA_1	Ordering cost FA_1	Includes the costs of purchase, supplies and transfer	Costs Management
FA_2	The cost of management and coordination of supply chain		Costs Management
FA_3	Costs and revenues management system		Costs Management & Revenue Management
FA_4	Financial stability	Shareholding status of the supplier company	Costs Management
FA_5	Working Capital Supplier		Costs Management

Table 2. The Criteria of the Customer Aspect for Selection and Evaluation of the Suppliers' Performance

Code	Criteria	Explanations	Strategic Objectives of the Hospital
CU_1	Responsiveness to the customer	Appropriate responsiveness to the needs of the customers (hospital and patients), responsiveness to the complaints and dissatisfactions and compensation of the damage	Customers satisfaction increase
CU_2	On-time delivery		Customers satisfaction increase
CU_3	Capability in delivering small orders	Out-of-program or spontaneous Orders	beneficiary satisfaction increase
CU_4	Geographical situation	Distance and vicinity of the supplier to the hospital and the patients	beneficiary satisfaction increase

Table 3. The Criteria of Internal Processes Aspect for Selection and Evaluation of the Suppliers' performance

Code	Criteria	Explanations	Strategic Objectives of the Hospital
IP_1	Past performance	Experience and Expertise	Performance Management Promotion
IP_2	The Quality of Provided Services	Adapted to the criteria and indices of hospital accreditation	Quality promotion and services standard
IP_3	Reliability		Performance Management Promotion
IP_4	Fame and credit of the supplier	The supplier's Stockholding status	
IP_5	Maintenance Time		Quality promotion and services standard, Function Management Promotion

Table 4. The Criteria of Development and Innovation Aspect for Selection and Evaluation of the Suppliers' performance

Code	Criteria	Explanations	Strategic Objectives of the Hospital
ED_1	The capability of solving problems	On-time and efficient management of the issues	Synergistic
ED_2	The extent of using information and telecommunications technology		Synergistic
ED_3	Advance Equipment Utilization		Synergistic
ED_4	innovation		Synergistic
ED_5	Educational and Improvement Programs	General Educational programs and Transferring knowledge to the Hospital, Personnel educational programs	Synergistic, Organization's Culture Development

causes perplexity. Therefore, to achieve adaptability between identification of the general criteria and the hospital supply chain, it seemed that in addition to the criteria derived from the literature review, the opinions of the internal experts (hospital quality manager, hospital manager, human resources manager, head of the hospital and the person in charge of outsourced wards) are to be obtained and considered by Delphi method. Subsequently, the identified criteria were adapted with the BSC aspects. The BSC and selected teaching hospital strategic objectives are shown in the Figure 2.

The identified criteria and adapted with BSC and selected teaching hospital strategic objectives have been provided in Tables 1-4.

A Hybrid Approach Study

A multi-index decision is a mathematical model, and it refers to an approach to problem solving that is used to select an option from a limited number of options. Multi-index methods are easy to use, hybrid procedures can maintain these strengths and create multiple sources of knowledge and experience, therefore, this study uses a combination of two approaches A and B, which compensate for each other's weaknesses with other strengths, in order to achieve more efficient decisions.

TOPSIS was first introduced by Hang. The only subjective data needed for the TOPSIS method is the importance of the metrics that make this approach attractive to decision makers. The underlying logic of the TOPSIS method (arranging preferences with similarity to the ideal solution) is to define positive and ideal negative solutions, which are based on the choice of the shortest distance to the ideal solution. The ideal positive and negative solution is a hypothetical solution in which all index values are the same as the maximum and minimum index values in the database, respectively. In short, the ideal positive solution is a combination of the best values of the criteria available and the ideal negative solution contains the worst values of the criteria available.

The AHP method combines the opinions of the experts, converting the complex decision-making system into a simple hierarchical system. Then, using pairwise comparisons, the scaling method is used to evaluate the relative importance.

Step 2: Weighing Criteria by FAHP

Designing the Pairwise Comparison and the Decision Matrices

The most important step in selection and evaluation of suppliers is to identify the appropriate evaluation criteria; thus based on the previous studies as well as the hospital experts 19 criteria are determined for the selection and evaluation of hospital outsourcing service suppliers[4] based on the BSC.

Defining Fuzzy Numbers for Paired Comparison

Fuzzy numbers used in this study are shown in Table 6. Then paired matrices were designed based on criteria and hierarchical model and were given to 15 hospital experts, managers and officials in Tehran.

Decision Matrix

Because of the numerous sub criteria (n=19) to complete the decision matrix, first the results are weighted and the

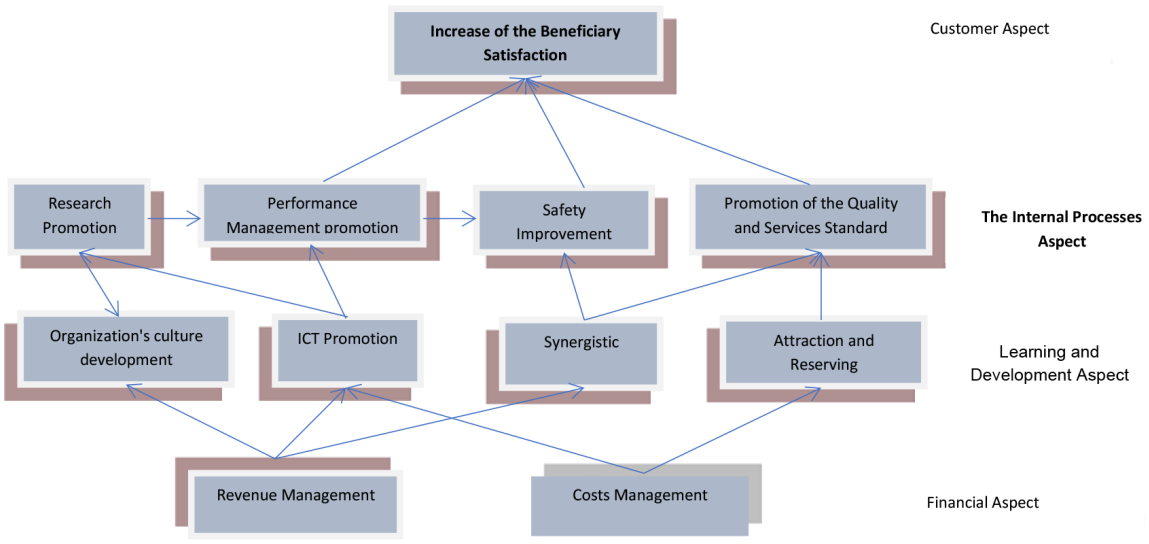

Figure 2. The Balanced Scorecard - Selected Teaching Hospital Strategic Objectives.

criteria are prioritized. Based on the results of this phase the criteria with higher priority are considered supplier selection and evaluation. Then the matrix is presented to the experts and they are asked to score the access of each supplier to each criterion. Accordingly, they are asked to allocate them the scores between 1 and 9 (Table 6).

Formation of Paired Matrix Using Fuzzy Numbers

FAHP Calculations

Step 1: The fuzzy composition value of $\widetilde{s_i}$ is calculated with i criteria using equation 1.

$$\widetilde{s_i} = \sum_{j=1}^{m} M_{gi}^{j} \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j} \right]^{-1}, \; i = 1, 2, 3, \ldots, n$$

In which $\otimes$ means wide multiplying of two fuzzy numbers and each of fuzzy numbers obtained represents a relative weight of a criterion (or option) to another criterion.

Step 2. If $\widetilde{M_1}$,$\widetilde{M_2}$ are two triangular fuzzy numbers, greatness degree of $\widetilde{M_2} = (l_2, m_2, u_2) \geq (l_1, m_1, u_1)$ is defined using the following equation.

$$\mu(d) = \begin{cases} 1 & m_2 \geq m_1 \\ \dfrac{u_1 - l_2}{(u_1 - m_1) - (m_2 - l_2)} & otherwise \\ 0 & l_1 \geq u_2 \end{cases}$$

In the above equattion

$\mu(d) = v(\widetilde{M_2} \geq \widetilde{M_1}), \widetilde{M_1} = (l_1, m_1, u_1), \widetilde{M_2} = (l_2, m_2, u_2)$.

Step 3: the possibility degree of a convex fuzzy number is greater than the possibility degree k of convex fuzzy number $\widetilde{M_i}\,(i = 1, 2, \ldots, k)$.

$$V\left(\tilde{M} \geq \overset{i}{M}_1, \widetilde{M_2}, \ldots, \widetilde{M_k}\right) = V\left(\tilde{M} \geq \widetilde{M_1}\right) and \; V\left(\tilde{M} \geq \widetilde{M_2}\right)$$

$$and \ldots . and \; V\left(\tilde{M} \geq \widetilde{M_k}\right) = \min V\left(\tilde{M} \geq \widetilde{M_k}\right), i = 1, 2, \ldots, k$$

Step 4: Following normalization of $\acute{W}$ normalized weight vector is calculated according to the following formula in which W is a non-fuzzy number.

$$W = \left(d(A_1), d(A_2), \ldots . d(A_n)\right)^T$$

Compatibility of paired comparison matrices in AHP is one of the most important issues that should always be considered in the decision process. If the incompatibility is less than 0.1 judgments are acceptable. In this study, to check the compatibility of judgments, at first, defuzzification of area center method and then traditional hierarchical analysis relationship were used.

Step 3: Select of Supplier by FTOPSIS

FTOPSIS Calculation for Selection and Evaluation of Suppliers

At this phase, based on the weight of the sub-criteria analysis, suppliers were selected and evaluated using fuzzy TOPSIS approach.

Results

As mentioned in the previous sections the selection criteria and sub-criteria and evaluation of suppliers based on BSC are analyzed by combining the FAHP and FTOPSIS. First the criteria and sub-criteria are weighted and prioritized based on FAHP and then based on the weights obtained for the criteria the suppliers are prioritized based on FTOPSIS approach the results of which are as follows:

Step 2: Prioritizing the Financial Dimension Criteria

Based on the studies and experts' opinion 5 financial criteria are identified to assess the suppliers and prioritized based on the fuzzy hierarchical analysis and the results of calculation are presented in Figure 3.

As can be seen Figure 3, suppliers' working capital, financial stability and supply chain management and coordination cost criteria have the highest priorities than other criteria, respectively.

Prioritizing the Customer Dimension Criteria

Various criteria based on customer dimension were observed in analyzing the conducted studies in the selection and evaluation of suppliers. After analyzing and consultation with experts 4 criteria associated with the hospital outsourcing service suppliers were selected to

Table 6. Decision Matrix

	Indicator 1	Indicator 2	Indicator 3	Indicator 4	Indicator 5	Indicator 6	Indicator 7	Indicator 8	Indicator 9	Indicator 10
Supplier 1										
Supplier 2										
Supplier 3										

select and evaluate suppliers and weighted and ranked by FAHP; the results of which are presented in Figure 4. As can be seen in Figure 4, the criteria of this dimension are almost at the same level according to the experts' and their weights are not significantly different. Customer responsiveness and timely delivery have higher priority than the other two criteria, respectively.

Prioritizing the Internal Processes Dimension Criteria

Five criteria of service quality, past performance of suppliers, repair time, reputation and supplier's reliability are considered to rank outsourcing service suppliers in hospitals; these criteria are ranked and weighted in Excel program by FAHP and the results of calculations can be seen in Figure 5.

As can be seen in Figure 5, the criteria of this dimension of experts' opinion have almost the same impact on the selection and evaluation of suppliers; based on the calculated weights the three criteria of service quality, past performance of suppliers and repair time (removal of defects) have higher impact than other criteria on suppliers' selection and evaluation.

Prioritizing the Growth and Learning Dimension Criteria

Six criteria of problem-solving capability, the use of information and communication technologies, the use of advanced technologies, innovation and educational programs in growth and learning are weighted by AHP; the results of calculations can be seen in Figure 6.

Prioritizing the BSC Dimensions

In Hashemi-Nejad Subspecialty Hospital staff and units' evaluation is conducted based on the BSC. In current study, to integrate with hospital policy, suppliers' evaluation is performed based on BSC. To determine which BSC criteria are more effective in supplier selection and evaluation according to the experts' opinion, these four dimensions are evaluated and weighted based on FAHP that the results of calculations are observed in Figure 7.

As can be seen in Figure 7, the customer and financial dimensions have higher importance than the other two dimensions of the BSC in the selection and evaluation of the outsourced service criteria at the hospital.

Final Prioritization of Supplier Selection and Evaluation Criteria

In the previous sections each criterion in its associated dimension was compared and prioritized based on the other criteria in that dimension. To compare all criteria the weight of each criterion was multiplied by the weight of its corresponding dimension to calculate the final weight of that criterion; then the obtained weights were normalized and the final result is presented in Figure 8.

As can be seen in Figure 8, customer responsiveness, suppliers' working capital, financial stability and timely delivery have the highest priorities and reliability, reputation, repair time and performance (experience and expertise) criteria have the lowest priorities.

Step 3: Supplier Selection Using Fuzzy TOPSIS Approach

At this point suppliers are prioritized using the weight of the obtained criteria in the previous stage and the fuzzy TOPSIS approach. Fuzzy TOPSIS approach calculations

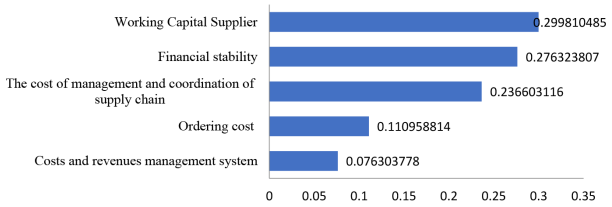

Figure 3. Prioritizing the Financial Dimension Criteria.

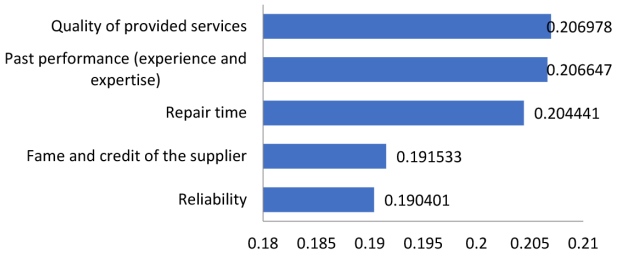

Figure 5. Prioritizing the Internal Processes Dimension Criteria.

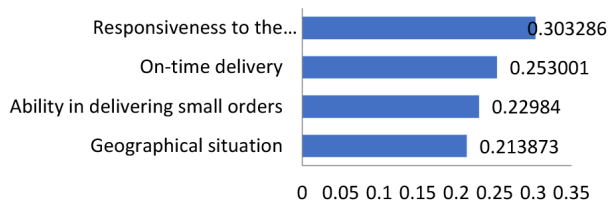

Figure 4. Prioritizing the Customer Dimension Criteria.

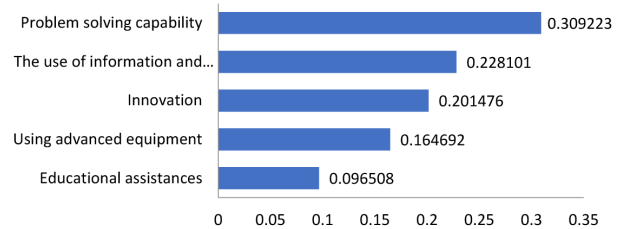

Figure 6. Prioritizing the Growth and Learning Dimension Criteria.

Table 7. Triangular fuzzy numbers used in research

Fuzzy number	9	7	5	3	1	1
Definition	Absolute importance	Very strong importance	Strong importance	Low importance	Equal importance	Exactly equal importance
Triangular fuzzy scale	(7,9,9)	(5,7,9)	(3,5,7)	(13,5)	(1,1,3)	(1,1,1)

are done in the Excel spreadsheet software.

The results of calculations for the three surveyed suppliers presented as A_1, A_2 and A_3 are shown in Table 7.

As can be seen in Table 7, the score of two supplies A_2 and A_3 is approximately the same. This result is mathematically and scientifically correct and management can choose either of these options based on hospital policies.

Conclusions

The provided BSC presented by Kaplan and Norton can only be applied for inside the organization evaluations and is not appropriate for the inter-organization evaluations in the supply chain, especially for those of the health supply chain; therefore, in this article initially the BSC was adapted with health supply chain point of view, then considering the opinions of the masters, the evaluation criteria were defined for each one of the Score Card aspects.

As described earlier, according to the experts customer and financial dimensions of the BSC have higher priority than the other dimensions in the selection and evaluation of outsourced service suppliers in hospitals and hospital managers should consider the criteria of this dimension in selecting the suppliers; also as it can be observed in the overall comparison of the criteria, customer responsiveness, suppliers' working capital, financial stability and timely delivery criteria have the highest priorities respectively and reliability, reputation, repair time and past performance (experience and expertise) criteria have the lowest priorities. The 6 prior criteria are more likely to be associated with the customer and financial dimensions; thus it is advised to the managers and hospital officials to consider these criteria in their assessments of suppliers.

In this research, based of supply chain concept and using BSC approaches, criteria are defined. Other researchers highlighted the importance of the supply chain in selecting hospital supplier evaluation criteria. Among these are the research by Asadi and his colleagues. The researchers first prioritized the criteria for selecting and evaluating suppliers in the three domains of service characteristics, supplier characteristics and supply chain relationships using the hierarchical analysis method, then prioritized Landry hospital suppliers.[32] Other researchers did not directly address the supply chain, but included criteria related to supply chain in their evaluation. Among the most prominent are the Amini and Abdolzadeh Mogadam Teimourlo research, which took into account criteria such as timely delivery, track record and supplier credibility; The criteria were used.[33] But Vali Aftari and Mir Ghafouri considered timely delivery metrics, payment terms, reliable history and supply chain-related service to assess food (perishable supply chain) among other criteria.[34] Low et al considered supply chain integration and supplier professionalism criteria in addition to other criteria such as system functions, service quality, and economics for selecting and evaluating hospital information system service providers, and selected criteria using a series analysis method. Fuzzy hierarchies were ranked.[35]

Since multi-criteria decision-making approaches are expert-oriented, fuzzy logic was used in this research. as

Table 8. Supplier Selection Using Fuzzy TOPSIS Approach

Ranking	**Score**	**Supplier**
First	0.538	A3
Second	0.529	A2
Third	0.473	A1

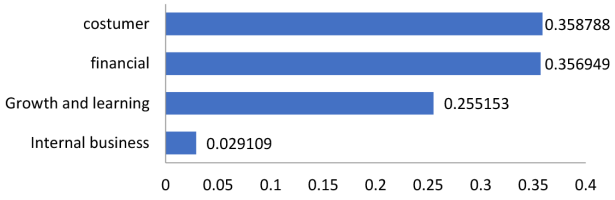

Figure 7. Prioritizing the BSC Dimensions.

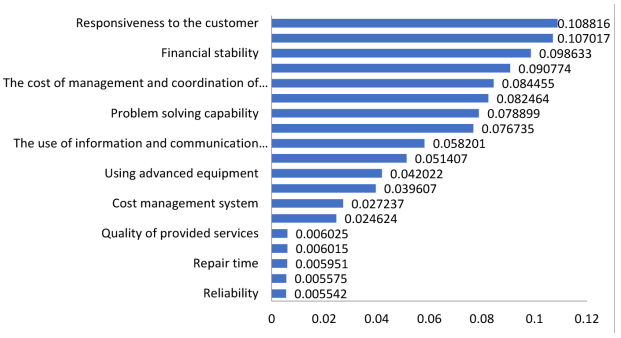

Figure 8. Final Prioritization of Supplier Selection and Evaluation Criteria.

many researchers have already mentioned, combining multi-criteria decision-making approaches and fuzzy logic to prioritize selection and evaluation criteria.[23,26-35]

According to opinion of experts, customer response criteria, supplier credibility, supplier financial stability, and timely delivery are more important than other selection criteria. This is almost consistent with work of Amini and Abdolzadeh Mogadam Teimourlo. In their research, trust, timely delivery and quality of service were the top priorities.[34]

Determining the criteria for assessing suppliers in the form of four BSCs and based on the strategic objectives of the organization in the supply chain, provides an effective tool for selecting and evaluating suppliers to the managers of the organization.

Utilizing the proposed approach can provide a simple, transparent, scientific, and innovative process for analyzing and prioritizing the suppliers as one of the most important and critical organizational decisions.

The study was based on the need for hospital managers to select newly outsourced services. On the other hand, the results of the present study should be made available to hospital managers to exploit the supplier selection.

Abbreviations

Balance Score card (BSC), Supply Chain (SC), Fuzzy TOPSSIS (F-TOPSSIS), Multi-Criteria Decision Making (MCDM), Fuzzy Analytic Hierarchy Process (FAHP).

Competing Interests

The authors declare no competing interests

Authors' Contributions

RA has been collecting data, solving the model, analysing the results, and writing the article. PS participated as a hospital advisor in this research.

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References

1. de Boer L, Labro E, Morlacchi P. A review of methods supporting supplier selection. Eur J Purch Supply Manag. 2001;7(2):75-89. doi:10.1016/S0969-7012(00)00028-9
2. Zhang Z, Lei J, Cao N, To K, Ng K. Evolution of supplier selection criteria and methods. Proceedings of the Second Globelics Conference Innovation Systems and Development, Emerging Opportunities and Challenges; 2004; Beijing, China.
3. Lee EK, Ha S, Kim SK. Supplier selection and management system considering relationships in supply chain management. IEEE Trans Eng Manag. 2001;48(3):307-318. doi:10.1109/17.946529
4. Ghotbuee A, Hemati M, Fateminezhad R. An empirical study based on BSC-DEA to measure the relative efficiencies of different health care centers in province of Semnan, Iran. Manag Sci Lett. 2012;2(7):2643-50. doi:10.5267/j.msl.2012.06.042
5. Hemati M, Danaei A, Shahhosseini M. An empirical study to measure the relative efficiency and strategic planning using BSC-DEA and DEMATEL. Manag Sci Lett. 2012;2(4):1109-1122. doi:10.5267/j.msl.2012.03.008
6. Jalaliyoon N, Zarei A, Hemati M. Consideration of BSC and EFQM as a Combination Framework. International Conference on Economics, Business and Management; 2011.
7. Hemati M, Zarei A, Karami M, Karkehabadi H. A hybrid algorithm of BSC and QFD to determine the criteria affecting implementation of successful outsourcing. Manag Sci Lett. 2002;2(2):655-664. doi:10.5267/j.msl.2011.11.002
8. Danesh Asgari S, Haeri A, Jafari M. Integration of Balanced Scorecard and Three- stage Data Envelopment Analysis Approaches. Iranian Journal of Management Studies. 2017;10(2):527-550. doi:10.22059/ijms.2017.222588.672419
9. Danesh Asgari S, Haeri A, Jafari M. Right indicators of urban railway system: combination of BSC and DEA model. International Journal of Transportation Engineering. 2018;5(3):275-299. doi:10.22119/ijte.2018.49732
10. Akhavan P, Shirazi H, Sabzaligol A, Pezeshkan A. A framework for organizational knowledge assessment by combining BSC and EFQM: a case of Beasat Industry Complex, Iran. IUP Journal of Knowledge Management. 2013;11(2):7.
11. Naseri A, Sepehri M, Mahmoudi S. Strategic performance evaluation of Health, Safety and Environment (HSE) based on Balanced Scorecard (BSC), the case study of a corporation in energy industry. Iran Occupational Health Journal. 2014;11(1):79-94. [Persian].
12. Safaei Ghadikolaei A, Chen IS, Hashemkhani Zolfani S, Akbarzadeh Z. Cause and Effect Relations of BSC in Universities of Iran. International Journal of Management & Innovation. 2011;3(2):16-25.
13. Safaei Ghadikolaei A, Chen IS, Hashemkhani Zolfani S, Akbarzadeh Z. Using DEMATEL method for cause and effect relations of BSC in universities of Iran. The 1st International Symposium and 10th Balkan Conference on Operational Research (BALCOR); 2011.

14. Hashemkhani Zolfani S, Safaei Ghadikolaei A. Performance evaluation of private universities based on balanced scorecard: empirical study based on Iran. Journal of Business Economics and Management. 2013;14(4):696-714. doi:10.3846/16111699.2012.665383
15. Hashemkhani Zolfani S, Safaei Ghadikolaei A. Application of MCDM methods in short-term planning for private universities based on balanced scorecard: a case study from Iran. Int J Product Qual Manag. 2012;10(2):250-266. doi:10.1504/IJPQM.2012.048299
16. Akarte MM, Surendra NV, Ravi B, Rangaraj N. Web based casting supplier evaluation using analytical hierarchy process. J Oper Res Soc. 2001;52(5):511-522. doi:10.1057/palgrave.jors.2601124
17. Muralidharan C, Anantharaman N, Deshmukh SG. A multi-criteria group decisionmaking model for supplier rating. J Supply Chain Manag. 2002;38(3):22-33. doi:10.1111/j.1745-493X.2002.tb00140.x
18. Chan FTS. Interactive selection model for supplier selection process: an analytical hierarchy process approach. Int J Prod Res. 2003;41(15):3549-3579. doi:10.1080/0020754031000138358
19. Chan FTS, Chan HK. Development of the supplier selection model—a case study in the advanced technology industry. Proc Inst Mech Eng B J Eng Manuf. 2004;218(12):1807-1824. doi:10.1177/095440540421801213
20. Liu FHF, Hai HL. The voting analytic hierarchy process method for selecting supplier. Int J P rod Econ. 2005;97(3):308-317.
21. Chan FTS, Chan HK, Ip RWL, Lau HCW. A decision support system for supplier selection in the airline industry. Proc Inst Mech Eng B J Eng Manuf. 2007;221(4):741-758. doi:10.1243/09544054jem629
22. Hou J, Su D. EJB-MVC oriented supplier selection system for mass customization. J Manuf Technol Manag. 2007;18(1):54-71. doi:10.1108/17410380710717643
23. Chan FTS, Chan HK. An AHP model for selection of suppliers in the fast changing fashion market. Int J Adv Manuf Technol. 2010;51(9):1195-1207. doi:10.1007/s00170-010-2683-6
24. Kumar J, Roy N. Analytic hierarchy process (AHP) for a power transmission industry to vendor selection decisions. Int J Comput Appl. 2011;12(11):26-30. doi:10.5120/1727-2336
25. Benyoucef M, Canbolat M. Fuzzy AHP-based supplier selection in e-procurement. International Journal of Services and Operations Management. 2007;3(2):172-92. doi:10.1504/IJSOM.2007.012136
26. Karsak EE, Dursun M. An integrated fuzzy MCDM approach for supplier evaluation and selection. Comput Ind Eng. 2015;82:82-93. doi:10.1016/j.cie.2015.01.019
27. Rahiminezhad Galankashi M, Helmi SA, Hashemzahi P. Supplier selection in automobile industry: a mixed balanced scorecard–fuzzy AHP approach. Alex Eng J. 2016;55(1):93-100. doi:10.1016/j.aej.2016.01.005
28. Zouggari A, Benyoucef L. Simulation based fuzzy TOPSIS approach for group multi-criteria supplier selection problem. Eng Appl Artif Intell. 2012;25(3):507-519. doi:10.1016/j.engappai.2011.10.012
29. Esmailian M, Rabieh M. Suppliers evaluation and selection using Fuzzy TOPSIS method and fractional programming. 5th International Conference on Industrial Engineering; Iran; 2007.
30. Beikkhakhian Y, Javanmardi M, Karbasian M, Khayambashi B. The application of ISM model in evaluating agile suppliers selection criteria and ranking suppliers using fuzzy TOPSIS-AHP methods. Expert Syst Appl. 2015;42(15-16):6224-6236. doi:10.1016/j.eswa.2015.02.035
31. dos Santos BM, Godoy LP, Campos LMS. Performance evaluation of green suppliers using entropy-TOPSIS-F. J Clean Prod. 2019;207:498-509. doi:10.1016/j.jclepro.2018.09.235
32. Asadi R, Etemadian M, Shadpour P, Semnani F. Designing a model of selection and assessment of hospital outsourcing services based on Approach Hierarchical Possess (AHP) in Hospitals. Journal of Hospital. 2018;16(4):9-18. [Persian].
33. Amini A, Abdolzadeh Mogadam Teimourlo S. Presenting a Model of Evaluation and Selection of Hospital Food Suppliers in Uncertainty Environment. Esfahan, Iran: National Conference on Modern Research in Industrial Management and Engineering; 2018. [Persian].
34. Vali Aftari N, Mir Ghafouri S. H. Evaluation and Selection of Health Care Providers and Determining Ordering Patterns Using Neural Network Techniques (Case Study: Yazd [Selected Hospital) [thesis]. Yazd: Bahonar university - Faculty of Management and Accounting; 2012. [Persian].
35. Low C, Hsueh Chen Y. Criteria for the evaluation of a cloud-based hospital information system outsourcing provider. J Med Syst. 2012;36(6):3543-3553. doi:10.1007/s10916-012-9829-z

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