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Performance evaluation of outsourcing decision using a BSC and Fuzzy AHP approach: A case of the Indian coal mining organization

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ABSTRACT

Mineral and mining sectors are always of a great concern to any nation due to its major contribution to the economy. In India, the demand for coal is continuously on rise due to its ever increasing need from the growing power sectors and steel industries. In spite of the large coal reserves, India has to import coal from overseas sources to address the perpetual demand-supply gap. In order to reduce the dependence on imported coal, to ensure an affordable price to the domestic customers as well as to achieve operational efficiency, the state-owned coal mining organization of India have now started taking initiatives to outsource some of the operational activities involving private agencies. To realize the success of outsourcing, it is indispensable to consider it as part of the corporate decision. Such decision essentially considers all possible attributes of strategy planning for performance improvement. The study focuses on the development of an effective performance evaluation framework based on Balanced Scorecard (BSC) and Fuzzy Analytic Hierarchy Process (FAHP) to analyze the suitability of organization's strategic decision of outsourcing in alignment with the organizational performance for the Indian coal mining organization. BSC administers strategic elements of decision making in assessing the performance of the firm whereas FAHP, on the other hand, is applied to determine the relative importance weight of criteria in regard to organizational objectives taking into consideration the vagueness and ambiguity of information as characteristics of decision-making problems. The findings of the present study establish the proposed framework as an analytical tool in strategy formulation and provide rationale guidance to management with regard to performance improvement.

1. Introduction

Mineral and mining sectors are the major contributors to the economic development of a country as they act as a primary source of raw materials to a wide range of industries. The Indian coal mining industry plays a significant role in terms of meeting the escalating demand for coal from the growing power sectors and steel industries. In spite of India being ranked fourth in the total coal reserve and third largest coal producing country in the world, a steady growth of demand-supply gap has been witnessed over the years. The continuously increasing demand has compelled the Indian coal mining organization to import coal from overseas sources. However, the import of coal is associated with several risks including global spot price movements, fluctuations in foreign currency exchange rate, and issues related to changes in laws and taxation in exporting countries. On the other hand, development of new domestic mines requires significant capital investment, higher operating costs, and maintenance of high level of spares. The resulting implication of all these factors is a substantial increase in the price of coal that is made available to the domestic customers (ICC, 2013). Simultaneously, it has been observed that private agencies have delivered competitive advantage to captive mines through the deployment of high capacity equipment and application of their expertise in modern exploration technologies. Moreover, private agencies are equipped with the state-of-the-art mining methods and planning skills that have led to efficient execution (ICC, 2013). As a result, the state-owned coal mining organization has now started taking initiatives involving the private agencies. This has the purpose of increasing the efficiency of the mining operation, lowering the operational cost while minimizing the wastes and increasing the sustainability of mining operation (Khanna, 2013).

For mining industries, non-core business processes have been the primary candidates for outsourcing (Kumar and Kumar, 2004). However, mining industries are recently outsourcing activities in regard to financial management, marketing, environmental management, employee management, and activities related to corporate social responsibilities (Sivakumar et al., 2015). According to Indian Chamber

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of Commerce Report (2013), overburden removal and logistics are the areas where outsourcing was practiced initially that has extended to core areas like exploration (ICC, 2013). Such endeavor has improved the quality of geological information that in turn minimizes the failure rates in target achievement and assists to derive better financial returns. Activities that are critical to the coal mining organization include identification of coal reserves, exploration of new mine sites, design, implementation, and optimization of operational activities for extraction of coal. Engaging third party service provider for coal reserve identification and exploration of new mine projects substantiates it to be one of the strategic action plans to achieve the projected target (CIL, 2015).

While outsourcing has been an established corporate strategy worldwide to achieve competitive advantage, however, such a business decision is associated with some inherent risks that can jeopardize future business survival. Outsourcing, which is popularly known as a cost effective tool often becomes expensive due to undesirable transaction cost (Quinn, 1999). Other disadvantages of outsourcing include the unavailability of the vendor on a full-time basis, leakage of confidential information, cost escalation, and risk sharing (Stacey et al., 1999). There are instances where the Indian coal mining organization has reported dissatisfied results while delegated outsourcing jobs to the private agencies (NCL, 2015; SECL, 2015).

So, to realize the success of outsourcing, it is indispensable to consider it as part of the corporate decision. Such decision essentially considers all possible attributes of strategy planning for performance improvement. Integrating outsourcing within the strategic decision to achieve competitive advantage requires evaluating and monitoring of one's own internal performance. The study focuses on the development of an effective performance evaluation framework to analyze the suitability of organization's strategic decision of outsourcing in alignment with the organizational performance for the Indian coal mining organization. In particular, the study captures the influence of outsourcing decision on organizational performance.

The performance evaluation framework deployed in this study is an integrated framework comprising of the Balanced Scorecard (BSC) and Fuzzy Analytic Hierarchy Process (FAHP). BSC administers strategic elements of decision making in evaluating the performance of the firm. BSC approach is applied in terms of a hierarchical structure with its four perspectives (financial, customer, internal operations, and company learning and growth) along with the performance indicators corresponding to each of the perspectives (Wang et al., 2012). FAHP, on the other hand, is a multi-criteria decision-making tool that helps in determining the relative importance weight of criteria in regard to organizational objectives taking into consideration the vagueness and ambiguity of information as characteristics of decision-making problems (Huang et al., 2008). The objective of the study is to present an integrated performance evaluation framework based on BSC along with FAHP that helps in determining the relative importance of the BSC perspectives and its indicators through the linguistic judgment of decision makers. Furthermore, in view of the fuzzy (imprecise) nature of information, sensitivity analysis has been carried out taking into account the level of uncertainty and confidence of decision makers for prioritizing the BSC perspectives and their corresponding attributes. The novelty of the study is three-fold. First, the study captures the unexplored attributes within the BSC perspectives responsible for performance evaluation particularly for a coal mining organization. Second, is the development of a performance evaluation framework characterized by quantitative and qualitative judgements of decision makers. Third, is that the entire framework has been designed and evaluated using Microsoft Excel® 2010 platform which is another distinct feature of the proposed approach in comparison to the adoption of any other costly software.

2. Review of literature

The extant literature cites several performance measurement frameworks for measuring the performance of an organization. The present study discusses some of the prominent performance measurement frameworks from the existing literature.

2.1. A review of existing performance measurement frameworks

Purbey et al. (2007) and Anderson and Mcadam (2004) discuss a number of different performance measurement frameworks for evaluating the performance of an organization. The most popular performance measurement frameworks discussed in the study are balanced performance measurement matrix, performance measures for time-based competition, performance pyramid system, balanced scorecard framework, Brown's input, processes, outputs and outcomes framework, performance prism, Du Pont's pyramid of financial ratios, and Skandia AFS navigator.

Keegan et al. (1989) posit the balanced performance measurement matrix that considers cost as well as non-cost measures in the framework; however, the matrix does not clearly portray the links between the different dimensions of business performance. The performance pyramid system was developed by Judson (1990) is a hierarchical framework considering business performance measure with the business process view at different levels of the organization (Neely and Bourne, 2000). The time-based performance evaluation framework known as performance measures for the time-based competition was proposed by Azzone et al. (1991) which considers time as a strategy in responding to the changing environment in achieving competitive advantage. The framework reflects the efficiency (internal configuration) and effectiveness (external configuration) dimensions of performance measure within the organization (Anderson and Mcadam, 2004). Skandia AFS (1994), a Sweden financial service company developed Skandia navigator, measures intellectual capital as a management instrument. A notable feature of this model is that it considers intangible assets that are linked to guide benchmark dimensions Brown's (1996). input, processes, outputs, and outcomes framework is based on the significant difference between input, processes, outputs, and outcomes measures such that there is a cause-effect relationship where one influences the other (Brown, 1996). The performance prism is another performance measurement tool that comprises of five interrelated perspectives. They are stakeholder satisfaction, strategies, processes, capabilities, and stakeholder contribution. The prism is considered as a balanced framework that includes internal and external measures, financial and non-financial measures as well as measures efficiency and effectiveness as measures of organizational performance (Neely et al., 2001; Neely and Bourne, 2000). Du Pont's pyramid of financial ratios refers to a hierarchical structure that links a variety of financial ratios to return on investment at different organization levels, however, a number of shortcomings of the framework were outlined in the extant literature (Kennerley and Neely, 2002).

Kaplan and Norton (1992) introduced Balanced Scorecard (BSC) which is a comprehensive and multi-dimensional view of looking at the performance of the organization through the four perspectives as financial, customer, internal, and company learning and growth. The extant literature exemplifies BSC to be the most prominent management tool for evaluating the performance of a firm. According to Neely et al. (2001), the strength of the framework lies in the integration of different modules of organizational performance within a comprehensive framework. Another notable feature of this framework is that it explicitly links the different dimensions of the performance measure with the organizational strategy (Neely ,2002; Anthony and Govindarajan, 1998). state that it is a management tool that assists in focusing on organization, enhancing communication and integration, framing organizational objectives, and further facilitates in providing feedback on strategy. In particular, the framework measures

the organizational performance in alignment with the corporate strategy. Looking at these manifold strength of the framework, BSC has been deployed in the present study to measure the performance of the case organization.

2.2. The Balanced Scorecard (BSC)

Business strategies are the footprints to achieve the mission and vision of an organization. In assessing an organizations' endeavor in value creation and future growth, BSC is employed as a performance evaluation tool that helps in evaluating and developing strategy integrated into a comprehensive framework (Amado et al., 2012; Grigoroudis et al., 2012; Tjader et al., 2014). Managers often limit their decision in focusing on the short-term financial measure as indices for organizational performance without giving regards to customer development or organizational resource development which are also enablers for future growth and survival and long-term profitability of the firm (Hafeez et al., 2002; Lee et al., 2008; Martinsons et al., 1999; Tjader et al., 2014). In order to deal with this challenge, Kaplan and Norton (1992) introduced BSC that measures organizational performance through its four perspectives across financial, customer, internal operations, and company learning and growth. The intent is to capture short-term financial measures as well as long-term strategic objectives of the firm. The BSC perspectives are outlined as follows:

2.2.1. Financial perspective

The financial perspective includes the economic performance measures that are related to the profitability of the firm. The common financial measuring elements are return on investment, cash flow, economic value added, profitability and so on (Abdolshah et al., 2012; Cebeci, 2009; Shen et al., 2016; Yüksel and Dağdeviren, 2010).

2.2.2. Customer perspective

The customer perspective deals with the measures required to satisfy the expected target customers while administering the organizational performance in achieving those targets. Some of its measures are customer satisfaction, customer retention, market share, new customer acquisition (Agrawal et al., 2016; Chaharsooghi et al., 2016; Lee et al., 2008; Yüksel and Dağdeviren, 2010).

2.2.3. Internal operations perspective

The internal operations perspective deals with the operational activities to achieve the desired performance in satisfying customer demand. Those are the value chain activities in maintaining current and future needs that involve innovation, productivity operations, activities to improve operational efficiency, and after-sales services (Chaharsooghi et al., 2016; Lotfi et al., 2013; Shen et al., 2016; Wang et al., 2012).

2.2.4. Company learning and growth perspective

The company learning and growth perspective focuses on the development and motivation of the human resources within the organization. Such measures include employee satisfaction, training and career growth of employee, employee competency enhancement and retention and so on (Abdolshah et al., 2012; Agrawal et al., 2016; Tjader et al., 2014).

2.3. Fuzzy Analytic Hierarchy Process (FAHP)

Analytic Hierarchy Process (AHP), an MCDM tool, was developed by Saaty (1980). AHP is a unidirectional hierarchical relational model where both qualitative/subjective and quantitative judgments are measured based on relative importance assigned to each criterion that is incorporated at each level of the hierarchy. However, human judgments on qualitative aspects are imprecise in nature. AHP considers pairwise comparisons expressed in crisp real numbers (Saaty's nine point scale) which are incapable of capturing the vagueness or linguistic nature associated with the judgments provided by the experts (Yu, 2002; Zadeh, 1965). Hence to address the uncertainties, FAHP has been widely used over the conventional AHP. Instead of the traditional discrete numbers, FAHP uses Triangular Fuzzy Number (TFN) which is a special case of a trapezoidal fuzzy number that captures the vagueness/uncertainty of the judgments as preferences in the pairwise comparison matrix. Fig. 1 depicts the fuzzy set definition with triangular membership function that acts as inputs to preference matrix/judgment matrix. Unlike the traditional AHP, FAHP method entails fuzzy representation in the pairwise comparisons.

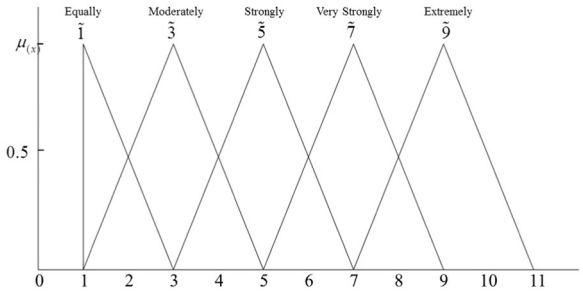

Fig. 1. Fuzzy set definition with triangular membership function.

2.4. Application of BSC-FAHP

Lee and Seo (2016) apply BSC-Fuzzy Delphi along with FAHP to address a cloud service selection problem where the four BSC perspectives represent the decision factors of the hierarchical structure whereas FAHP is applied to evaluate alternatives in the selection of the best cloud service. Singh et al. (2015) worked on sustainability evaluation for manufacturing SMEs where the key performance measures for sustainability are measured through the four perspectives of BSC while FAHP is used to determine the relative weights of the indicators. The study by Cebeci (2009) presents decision support system for ERP selection in a textile industry. BSC is applied to determine the vision, mission, strategies, and the key performance indicators whereas FAHP is used to provide relative priority weights to ERP attributes in selecting the best ERP package. Lee et al. (2008) propose a BSC and FAHP approach for performance evaluation of the IT department of a manufacturing industry in Taiwan, where BSC is exploited to determine the performance evaluation criteria and FAHP is used to determine the relative importance of the criteria and the performance indicators within them. Review of the existing literature ascertains the appropriateness of BSC as a performance measurement tool; however, there has been limited application of BSC in the mining sectors. Thus the study empirically investigates the suitability of BSC perspectives in measuring the performance of the Indian coal mining organization on account of an outsourcing decision.

3. Research methodology and collection of data

In order to identify the drivers and their relative importance for the evaluation of organizational performance on account of an outsourcing decision a case study has been conducted in the Indian coal mining organization. The study is based on the four perspectives of the BSC framework to determine their corresponding performance indicators, followed by an MCDM approach incorporating qualitative and quantitative judgment using FAHP for evaluating performance for the coal mining organization. Delphi technique has been applied to identify the BSC performance indicators and to determine their relative importance weights based on judgments of the decision-makers following the steps as discussed below. Delphi technique is based on group decision

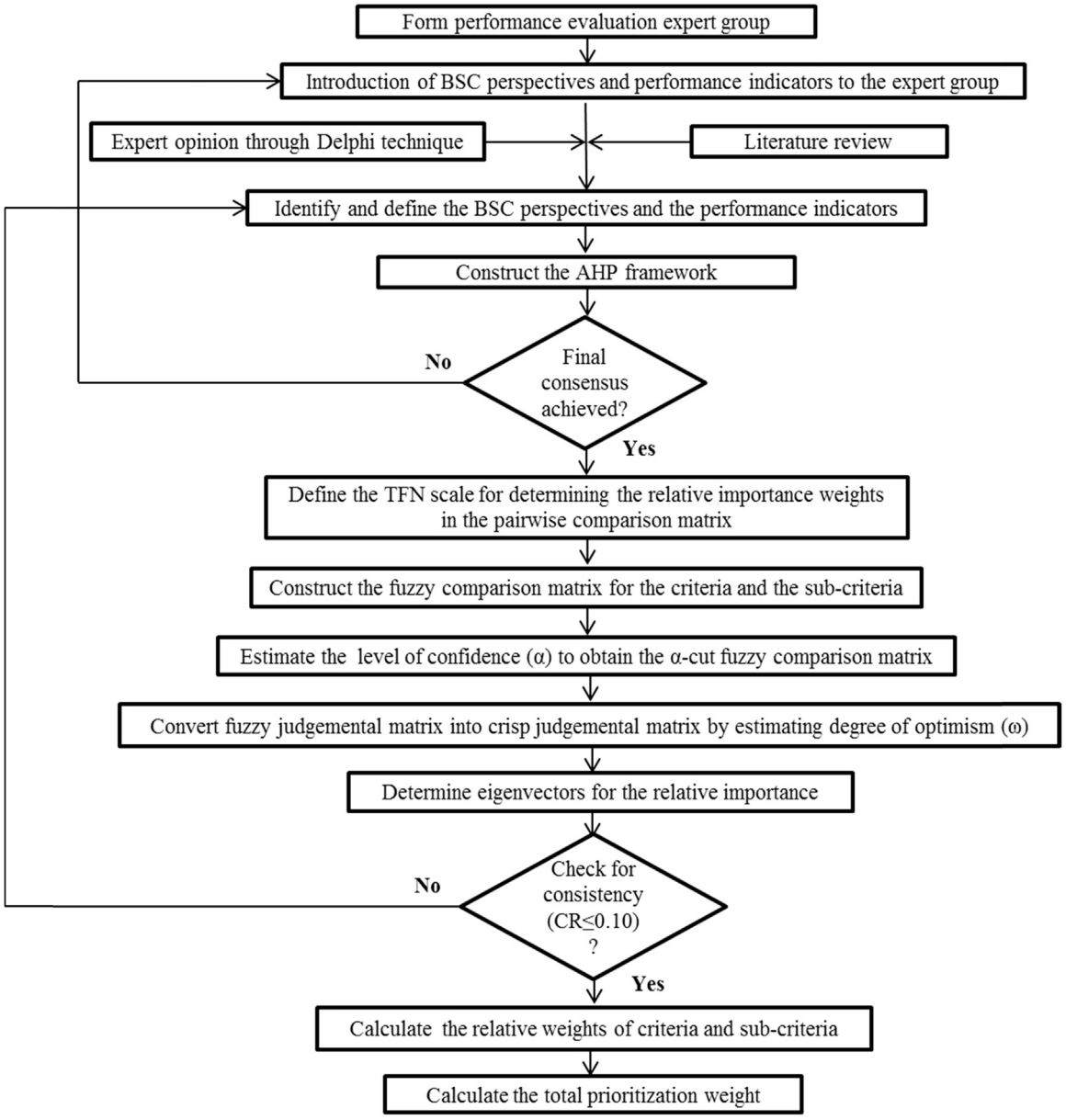

Fig. 2. Flow chart of the study.

making process and involves interaction between a group (member size varying between five to fifty) of identified experts (Delphi panel) and the researchers (acting as facilitators) for obtaining mutual consensus on a specific topic (Chang et al., 2008; Gumus, 2009; Hsu and Sandford, 2007; Yousuf, 2007). Identifying and selecting the panel of experts to match the scope and purpose of the Delphi study is often challenging as the validation of a Delphi study is largely determined by the selection of quality experts that mostly depends on the researchers' ability (Watkins et al., 2012). In Delphi, a heterogeneous mixture of panellists is recommended to overcome any potential bias in the selection of experts (Yousuf, 2007). The present study takes into consideration the different dimensions of performance measure integrated into a framework, thus selecting a dynamic panel of experts from diverse background (with respect to the experience and expertise) entail diverse perspectives about the focus area. According to literature, selecting participants with both conceptual and applied (practical) knowledge facilitates in better understanding the focus area (Watkins et al., 2012). The Delphi technique follows several steps to reach the final consensus. The steps involved in Delphi methodology are elaborated below:

- The first step is the formation of a performance evaluation Delphi panel. In the present research context, ten experts (each with a minimum work experience of ten years) having diverse functional background (general management, operations, excavation, safety, human resource) were selected from the Indian coal mining organization as panel members. Such that they were knowledgeable and competent enough to take business decisions on performance evaluation related to an outsourcing decision. As one of the authors is the director of the case organization, his experience, judgement, and intuition helped to reinforce the managerial and technical capacity of the selected panellists.
- The second step starts with an open-ended questionnaire which acts as an initiation to the discussion and allows exploring the topic in detail. In this step, the experts were introduced to the problem definition and its relation to the BSC framework. Then they were requested to express their views so as to list down the performance indicators within the BSC framework (customer, financial, internal operations, and company learning and growth) that influences the organizational performance. Citing similar literature facilitated an insightful understanding of the subject matter.

- In step three, based on the expert interview, 14 performance indicators were initially identified that were finally narrowed down to 11 within the four BSC perspectives that were found most relevant to the present context.
- In step four, based on the identified indicators, a hierarchical AHP structure was constructed by the researchers consisting of a goal, criteria, and sub-criteria. Construction of the hierarchical AHP model has been discussed in details in the subsequent section.
- In step five, a questionnaire was developed based on AHP format comparing each BSC perspective and its corresponding indicators.
- In step six, the respondents were introduced to the TFN scale so as to determine the relative importance of the BSC perspective and their indicators in the structured questionnaire.
- Subsequently, the final and detailed questionnaires were distributed among the experts requesting them to provide their responses based on linguistic judgment using TFN scale. Adequate guidelines were provided in the questionnaire to ensure an in-depth understanding leading to quality responses. At this phase, researchers investigate the rationale behind the ranking of the prioritized items.
- In the seventh step, the respondents were asked to review their responses on items and their ratings based on their knowledge and understanding. Any alteration in the responses provided was addressed immediately.
- Finally, the items were summarized with their relative ratings and delineated to the respondents for their final consensus.

The methodology adopted for the present study is shown in Fig. 2. Each of the stages of the solution methodology is discussed in subsequent sub-sections. The essential steps involved in the analysis and implementation of the BSC-AHP framework is summarized in the following sections.

3.1. Construction of AHP hierarchical model with decision elements

An AHP model which is hierarchical in nature is established with the topmost level as goal that defines the problem statement, the second level comprises of the four BSC perspectives as criteria whereas the third level consists of the performance indicators as sub-criteria within each perspective. For this study, the goal is defined as the evaluation of organizational performance associated with the outsourcing decision, criteria are the four BSC perspectives as financial, customer, internal operations, and company learning and growth whereas sub-criteria are the performance indicators within the BSC perspectives as presented in Fig. 3. A total of 11 performance indicators were found relevant within the four BSC perspectives. The performance indicators within financial perspective are profit variance, operational cost, and reduction of penalties whereas customer perspective comprises of indicators as availability and adherence to delivery schedule. Internal operations perspective includes indicators as adherence to statutory norms, production target achieved, and asset management whereas company learning and growth consists of training and development, research and development, and employee satisfaction. The identified BSC indicators related to each BSC perspective along with their definitions and source from literature have been enlisted in Table 1.

3.2. Construction of pairwise comparison matrix

AHP involves pairwise comparisons that use Saaty's nine-point scale at each level of the hierarchy to determine the relative importance of the decision elements. A nine-point scale uses crisp real numbers expressing preferences between options as equal, moderate, strong, very strong or extremely preferred that can be translated into pairwise weights of 1, 3, 5, 7, 9, respectively, with 2, 4, 6, and 8 as intermediate values as shown in Table 2 (Saaty, 1977). However, the conventional AHP scale of 1–9, that is discrete in nature, fails to capture the ambiguity related to the human estimation of qualitative characteristics which is subjective and ambiguous in nature. So, the classical AHP technique falls short of capturing the realistic view of human behavior which is imprecise in nature. In view of the aforementioned challenges in regard to the uncertainty of human judgment on qualitative attributes, triangular FAHP technique has been administered to determine the subjective relative importance weights of each decision element. FAHP technique is based on the elementary concept of pairwise comparison method between the criteria and sub-criteria in order to develop the comparison matrices.

A pairwise comparison on a given level is obtained to estimate the relative importance of the criteria and the sub-criteria. In FAHP, the sensitivity of the preferences is captured through the use of TFN in the pairwise judgemental matrix as shown in Fig. 1.

For this study, a questionnaire has been developed to determine the relative weights of the criteria (BSC perspectives) and sub-criteria (BSC performance indicators). Experts were requested to provide their preferences in the comparison matrices of the questionnaire using TFN from 1 to 9. The fuzzy judgment matrix is constructed using TFN that represents the preferences of the decision maker. Table 3 represents the pairwise comparison matrix of BSC perspectives based on the responses from decision maker 1(DM1). Similar pairwise comparison matrices for the sub-criteria were computed.

The fuzzy set is represented as $F = \{(x, \mu(x)), x \in U)\}$, where x takes its values on the real line, U is the universe of discourse and $\mu(x)$ is the membership function whose value lie in a closed interval between [0, 1] (Nepal et al., 2010).

The triangular type fuzzy membership function is presented as in Eq. (1).

$$\mu(x) = \begin{cases} 0, & x < l \\ \frac{x-l}{m-l}, & l \le x \le m \\ \frac{u-x}{u-m}, & m \le x \le u \\ 0, & x > u \end{cases} \quad (1)$$

The TFN can alternatively be defined by the interval of confidence level α or the α-cut and is presented using Eq. (2).

Let $\widetilde{M} = (l, m, u)$ represents the TFN where $(l \le m \le u)$ then

$$\widetilde{M}_\alpha = [l^\alpha, u^\alpha] = [(m-l)\alpha + l, -(u-m)\alpha + u] \quad \forall\ \alpha \in [0, 1] \quad (2)$$

Now, assigning the values of α,l^α, and u^α in Eq. (2) to obtain the α-cut fuzzy comparison matrix, where α is the interval of confidence and a value of 0.5 illustrates an average confidence of the decision maker while providing judgment in the pairwise comparison matrix. l^α and u^α are the lower limit and the upper limit of the fuzzy set defined in the fuzzy membership function. Table 4 shows the α-cut fuzzy comparison matrix for the criteria for DM1. Similar α-cut fuzzy comparison matrixes for the sub-criteria are determined.

3.3. Conversion of fuzzy judgment matrix into crisp judgment matrix

Next, to analyze the fuzzy judgment matrix it is converted into its fuzzy equivalent form as presented below (Kwong and Bai, 2002):

$$[a_{i1l}^\alpha x_{1l}^\alpha,\ a_{i1u}^\alpha x_{1u}^\alpha] \oplus \cdots \oplus [a_{inl}^\alpha, x_{nl}^\alpha,\ a_{inu}^\alpha x_{nu}^\alpha] = \lambda x_{il}^\alpha,\ \lambda x_{iu}^\alpha$$

where,

$$\widetilde{A} = [\widetilde{a}_{ij}],\ ,\quad \widetilde{x} = (\widetilde{x}_1, \ldots..\ , \widetilde{x}_n),$$

$$\widetilde{a}_{ij}^\alpha = [a_{ijl}^\alpha,\ a_{iju}^\alpha],\quad \widetilde{x}_i^\alpha = [x_{il}^\alpha,\ x_{iu}^\alpha] \text{ and } \widetilde{\lambda}^\alpha = [\lambda_l^\alpha,\ \lambda_u^\alpha]$$

$$\widetilde{\mathrm{a}}_{\mathrm{ij}}^\alpha = [\mathrm{a}_{\mathrm{ijl}}^\alpha,\ \ \mathrm{a}_{\mathrm{iju}}^\alpha],\ \ \widetilde{\mathrm{x}}_{\mathrm{i}}^\alpha = [x_{il}^\alpha,\ x_{iu}^\alpha] \text{ and } \widetilde{\lambda}^\alpha = [\lambda_l^\alpha,\ \lambda_u^\alpha]$$

Finally, the fuzzy judgment matrix is converted into crisp judgment matrix using Eq. (3).

$$\hat{a}_{ij}^\alpha = \omega a_{iju}^\alpha + (1-\omega) a_{ijl}^\alpha,\ \ \forall\ \omega \in [0, 1] \quad (3)$$

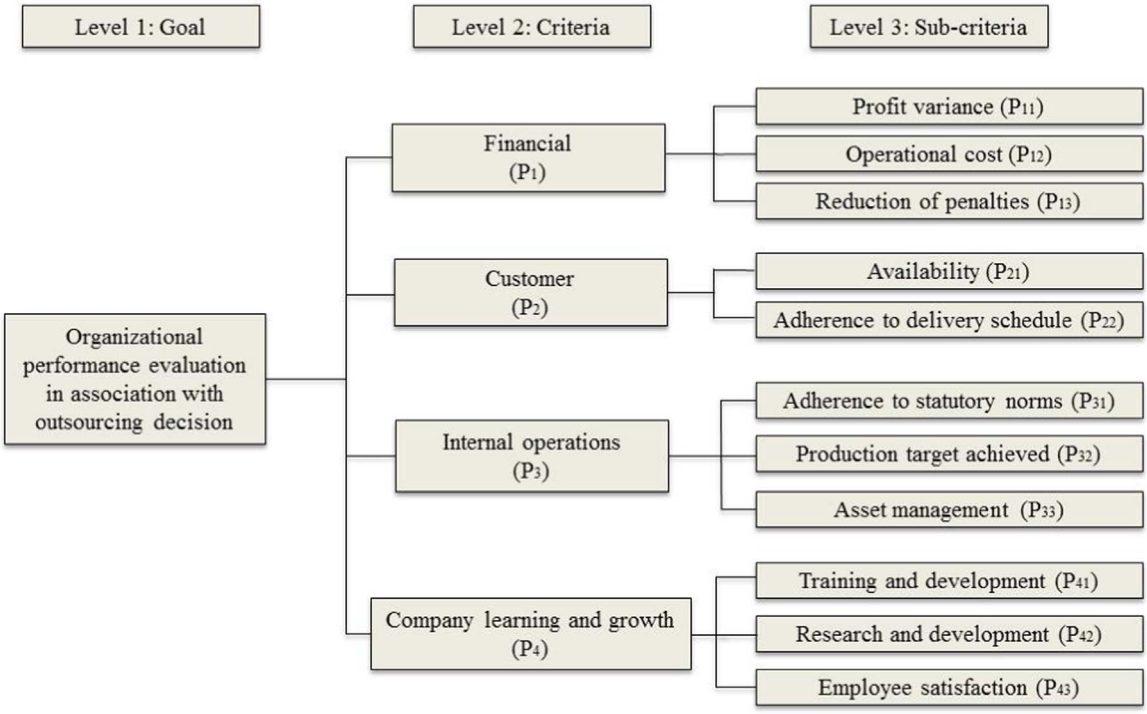

Fig. 3. Hierarchical representation of BSC decision criteria.

where, ω is known as the index of optimism that signifies the degree of optimism of the expert while decision making (Promentilla, 2006). When a value of ω is assigned to 0.5, it reveals that the judgments of the decision maker is neither too optimistic nor too pessimistic. α represents the interval of confidence also known as the level of uncertainty and reduced level of confidence. When α value is less than one it represents reduced level of confidence of a decision maker while providing preferences. δ signifies the degree of fuzziness. When the value of δ is 0 and that of α is 1, it exhibits the absence of fuzziness in the decision making. Fig. 4 represents triangular fuzzy set definition in terms of α-cut, ω, and δ (Nepal et al., 2010).

Using Eq. (3) and substituting the values of α and ω as 0.5, the fuzzy judgment matrix is converted into crisp judgment matrix. The values of α and ω depends on the problem definition that is based on the confidence/uncertainty level and attitude of decision maker against fuzziness. Table 5 represents the crisp pairwise comparison matrix of the criteria based on the responses from DM1.

3.4. Determination of the eigenvectors

To determine the value of w(prioritization weight) Eq. (4) is applied (Nepal et al., 2010).

$$w_i = \frac{\sum_{i=1}^{I}\left(\frac{aij}{\sum_{j=1}^{J} aij}\right)}{J} \tag{4}$$

where w_i is the relative importance of a criterion i. J represents the index number of columns in the pairwise matrix, whereas I is the index number of rows in the pairwise matrix and a_{ij} are the pairwise comparison values between elements i and j. Table 6 represents the pairwise comparison of the criteria along with their relative importance weights denoted as w_{Pi} for DM1.

Table 1
BSC performance measurement indicators with description.

BSC perspectives	Performance indicators	Description	Source
Financial	Profit variance	Variance between actual profit amount and budgeted profit amount	Shank and Govindarajan (1993), Valeriy (2015)
	Operational cost	Expenses related to operations of a business	Kaplan and Norton (1993)
	Reduction of penalties	Adherence to the recommendations of human safety and environmental protection	Epstein and Wisner (2001)
Customer	Availability	Product/service availability to customers	Lee and Seo (2016), Tjader et al. (2014)
	Adherence to delivery schedule	Delivery of orders as per the given schedule	Abdolshah et al. (2012)
Internal operations	Adherence to statutory norms	Conformance to standards and norms set by the regulatory bodies	Agrawal et al. (2016)
	Production target achieved	Conformance to actual production to target	Lawrence and Umesh (2002)
	Asset management	Systematic monitoring and maintenance of assets cost effectively	Kaplan and Norton (2000)
Company learning and growth	Training and development	Initiatives to improve performance of the employees	Lotfi et al. (2013), Singh et al. (2015), Yüksel and Dağdeviren (2010)
	Research and development	Research and development effort and success	Lotfi et al. (2013)
	Employee satisfaction	Satisfying employees based on wage and/or promotions	Cebeci (2009), Singh et al. (2015)

Table 2
The AHP pairwise comparison scale.

Numerical rating	Verbal scale	Description
1	Equal importance of both the elements	Both the elements are equally favored
3	An element is moderately important than the other	An element is favored over another based on experience and judgment
5	An element is strongly important than the other	An element is strongly favored over another
7	An element is very strongly important than the other	An element is very strongly favored over another
9	An element is extremely important than the other	An element is extremely favored over another
2,4,6,8	Intermediate values	In-between values used to negotiate between two judgments

Table 3
Fuzzy pairwise comparison matrix for BSC criteria with respect to overall goal.

BSC perspectives	P_1	P_2	P_3	P_4
P_1	1	1/3~	3~	5~
P_2	3~	1	5~	7~
P_3	1/3~	1/5~	1	3~
P_4	1/5~	1/7~	1/3~	1

Table 4
α-cut fuzzy comparison matrix for criteria.

BSC perspectives	P_1	P_2	P_3	P_4
P_1	1.000	[1/4, 1/2]	[2,4]	[4,6]
P_2	[2,4]	1.000	[4,6]	[6,8]
P_3	[1/4, 1/2]	[1/6, 1/4]	1.000	[2,4]
P_4	[1/6, 1/4]	[1/8, 1/6]	[1/4, 1/2]	1.000

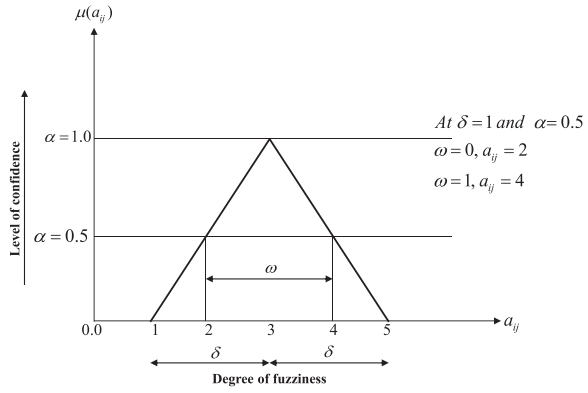

Fig. 4. Fuzzy set definition in terms of α,ω, and δ.

Table 5
Crisp pairwise comparison matrix of criteria.

BSC perspectives	P_1	P_2	P_3	P_4
P_1	1.000	0.375	3.000	5.000
P_2	3.000	1.000	5.000	7.000
P_3	0.375	0.208	1.000	3.000
P_4	0.208	0.146	0.375	1.000

Table 6
Pairwise comparison of criteria with their relative importance weights.

BSC perspectives	P_1	P_2	P_3	P_4	w_{Pi}
P_1	0.218	0.217	0.320	0.313	0.267
P_2	0.655	0.578	0.533	0.438	0.551
P_3	0.082	0.120	0.107	0.188	0.124
P_4	0.045	0.084	0.040	0.063	0.058

3.5. Consistency check of the pairwise comparisons

To check the consistency of the judgments provided by the decision makers,λ_{max}(maximum eigenvalue of the pairwise comparison matrix), *CI* (consistency index), and *CR* (consistency ratio) values for all pairwise comparison matrices are calculated. λ_{max} is calculated using Eq. (5) (Nepal et al., 2010).

$$Aw = \lambda_{max} w \tag{5}$$

where A is the crisp pairwise matrix and w is a column matrix of principal eigenvectors. To determine the values of *CI* and *CR*, Eqs. (6) and (7) are applied respectively.

$$CI = \frac{(\lambda_{max} - n)}{(n-1)} \tag{6}$$

$$CR = \frac{CI}{RI} \tag{7}$$

where n in the formula is the size of the matrix and *RI* is random consistency index. The standard values for *RI* are selected on the basis of the suggested values by Saaty (1980) as presented in Table 7.

Depending upon the size of the matrix, n, a fitting value of *RI* is selected to calculate *CR*. According to Saaty (1980), *CR* values of all pairwise comparison matrices are expected to be less than 0.1 for its consistency and acceptability. In this study, the *CR* values for all the pairwise comparison matrices have been found to be less than 0.1 which means that the values are consistent and acceptable. Table 8 shows the values of the importance weights (w_{Pi}), highest eigenvalue (λ_{max}),*CI*, and *CR* values for all the criteria for DM1.

3.6. Calculation of the relative weights of criteria and sub-criteria

When multiple decision makers are involved, it is necessary to aggregate their judgments into a single representative judgment for the entire group of respondents. As per literature, geometric mean has been proved to be the only correct way to aggregate such individual judgments (Aczel and Saaty, 1983). The total weights of each criterion (W_{Pi}) and total weights of each sub-criterion (W_{Pij}) were calculated taking into consideration the geometric mean of the individual relative weights (w_{Pi}) for all the decision makers from DM1 to DM 10. Table 9 presents the relative importance weights (w_{Pi}) of the criteria as P1, P2, P3, and P4 for all the decision makers for DM1 to DM 10. Finally, the total weight (W_{Pi}) of each criterion is calculated using geometric mean of the weights given by the individual decision makers towards that criterion (w_{Pi}). The relative importance weights (W_{Pij}) for all the sub-criteria (P_{11}, P_{12}, P_{13}, P_{21}, P_{22}, P_{31}, P_{32}, P_{33}, P_{41}, P_{42}, and P_{43}) were calculated in a similar way.

The importance weights of criteria (P_1,P_2, P_3, and P_4) sub-criteria (P_{11}, P_{12}, P_{13}, P_{21}, P_{22}, P_{31}, P_{32}, P_{33}, P_{41}, P_{42}, and P_{43}) for a

Table 7
Random consistency index values.

Size of Matrix	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.89	1.11	1.25	1.35	1.40	1.45	1.49

Table 8
Relative importance weights of criteria with λ_{max}, CI, and CR values.

BSC perspectives	P1	P2	P3	P4	w_{Pi}		
P_1	0.218	0.217	0.320	0.313	0.267		
P_2	0.655	0.578	0.533	0.438	0.551	λ_{max}	4.269
P_3	0.082	0.120	0.107	0.188	0.124	CI	0.090
P_4	0.045	0.084	0.040	0.063	0.058	CR	0.101

Table 9
Relative importance weights (W_{Pi}) of criteria.

Response #	P_1	P_2	P_3	P_4	λ_{max}	CI	CR
DM 1	0.267	0.551	0.124	0.058	4.269	0.090	0.101
DM 2	0.349	0.474	0.124	0.053	4.174	0.058	0.065
DM 3	0.242	0.570	0.098	0.090	4.227	0.076	0.085
DM 4	0.235	0.579	0.124	0.062	4.251	0.084	0.094
DM 5	0.213	0.646	0.083	0.058	4.286	0.095	0.107
DM 6	0.294	0.560	0.087	0.059	4.246	0.082	0.092
DM 7	0.272	0.557	0.102	0.069	4.204	0.068	0.076
DM 8	0.267	0.551	0.124	0.058	4.269	0.090	0.101
DM 9	0.275	0.555	0.093	0.077	4.279	0.093	0.104
DM 10	0.259	0.569	0.120	0.052	4.207	0.069	0.078
W_{Pi}	**0.267**	**0.561**	**0.108**	**0.064**	**4.241**	**0.080**	**0.089**

Table 10
Importance weights of criteria and sub-criteria for ω =0.5 and α =0.5.

α =0.5 ω =0.5	
BSC perspectives	Weight (W_{Pi})
Financial (P_1)	0.267
Customer (P_2)	0.561
Internal operations (P_3)	0.108
Company learning and growth (P_4)	0.064
α = 0.5 ω = 0.5	
Financial perspective (P_1)	Weight (W_{Pij})
Profit variance (P_{11})	0.611
Operational cost (P_{12})	0.288
Reduction of penalties (P_{13})	0.101
α = 0.5 ω= 0.5	
Customer perspective (P_2)	Weight (W_{Pij})
Availability (P_{21})	0.762
Adherence to delivery schedule (P_{22})	0.238
α = 0.5 ω = 0.5	
Internal operations perspective (P_3)	Weight (W_{Pij})
Adherence to statutory norms (P_{31})	0.110
Production target achieved (P_{32})	0.609
Asset Management (P_{33})	0.281
α = 0.5 ω = 0.5	
Company learning and growth (P_4)	Weight (W_{Pij})
Training and development (P_{41})	0.129
Research and development (P_{42})	0.199
Employee satisfaction (P_{43})	0.672

combination of α=0.5 and ω =0.5 were calculated following the above mentioned steps using geometric mean for DM1 to DM 10 and are represented in Table 10.

3.7. Calculation of overall prioritization weight of the sub-criteria

The next step is to calculate the total weights of the sub-criteria (BSC indicators). To calculate the total prioritization weight (TW_{Pij}) of sub-criterion, the relative importance weight of each sub-criterion (W_{Pij}) is multiplied by its corresponding relative importance of the criteria (W_{Pi}). Mathematically it can be expressed as given in Eq. (8).

$$TW_{Pij} = W_{Pi} * W_{Pij} \tag{8}$$

where TW_{Pij} is the overall prioritization weight for each sub-criterion, W_{Pi} represents the total weight of each criterion and W_{Pij} represents total weight of each sub-criterion. Table 11 below shows the summarized results of importance weights with rank order for all the sub-criteria at a moderate level of confidence and degree of optimism (ω =0.5 and α =0.5).

4. Results and discussion

Based on the inputs provided by the experts, the relative importance weights of the BSC perspectives (W_{Pi}) and BSC indicators (W_{Pij}) have been computed taking into consideration the geometric mean. To calculate the importance weights of all the criteria and sub-criteria the degree of optimism (ω) and confidence interval (α) have been assigned a value of 0.5 that represents average level of optimism and the average level of confidence interval of the decision maker respectively.

When the performance indicators are arranged in a decreasing order of importance weights, availability (P_{21}) within customer perspective possesses the highest value of 0.427 followed by profit variance (P_{11}) within financial perspective and adherence to delivery schedule (P_{22}) within customer perspective exhibiting weights as 0.163 and 0.134 respectively. Operational cost (P_{12}), production target achieved (P_{32}), and employee satisfaction (P_{43}) are the subsequent set of indicators with higher importance weights of 0.077, 0.066, and 0.043 respectively. Performance indicators such as asset management (P_{33}), reduction of penalties (P_{13}), and research and development (P_{42}) with weights as 0.03, 0.027, and 0.013 respectively demonstrate moderate to low importance. However, indicators such as adherence to statutory norms (P_{31}) with weight as 0.012 and training and development (P_{41}) with weight as 0.008 recede in the overall ranking. Thus the results portray the significance of the indicators in the evaluation of organizational performance on account of an outsourcing decision. Availability, profit variance, and adherence to delivery schedule are within the highest priority indicators that clearly portray their importance in achieving organizational performance which is in accord with the organization's corporate strategic planning. It can also be noted that outsourcing has enabled in achieving targeted production while emphasis should be given to the declining utilization of departmental capacities in terms of asset management which is among the low priorities. However, for the least priority indicators, it can be recommended that due importance should be given to statutory norms for environmental protection and human safety in view of the sustainable growth of the organization whereas indicators within company learning and growth should be encouraged consideration the depleting competencies of employees in the organization.

5. Sensitivity analysis

As stated, the prioritization of criteria and sub-criteria within each BSC perspective is based on the subjective judgment of the experts and the weights assigned to their level of confidence (α) and degree of optimism (ω). So it is necessary to observe the effect of importance weights with respect to changes in the values of α and ω. Hence, the

Table 11
Overall prioritization weights of criteria and sub-criteria.

Goal	Criteria (BSC perspectives)	Criterion rel. weight (W_{Pi})	Sub-criteria (BSC indicators)	Sub-criteria rel. weight (W_{Pij})	Total weight (TW_{Pij})	Rank
Evaluation of organizational performance associated with outsourcing decision	P_1	0.267	P_{11}	0.611	0.163	2
			P_{12}	0.288	0.077	4
			P_{13}	0.101	0.027	8
	P_2	0.561	P_{21}	0.762	0.427	1
			P_{22}	0.238	0.134	3
	P_3	0.108	P_{31}	0.110	0.012	10
			P_{32}	0.609	0.066	5
			P_{33}	0.281	0.030	7
	P_4	0.064	P_{41}	0.129	0.008	11
			P_{42}	0.199	0.013	9
			P_{43}	0.672	0.043	6

Table 12
Importance weights of the criteria with varying values of α and ω.

α =0 ω =0		α =0 ω =0.5		α =0 ω =1	
Criteria	Weight	Criteria	Weight	Criteria	Weight
Financial (P_1)	0.246	Financial (P_1)	0.276	Financial (P_1)	0.300
Customer (P_2)	0.571	Customer (P_2)	0.536	Customer (P_2)	0.507
Internal operations (P_3)	0.108	Internal operations (P_3)	0.118	Internal operations (P_3)	0.125
Company learning and growth (P_4)	0.069	Company learning and growth (P_4)	0.065	Company learning and growth (P_4)	0.063
α = 0.5 ω= 0		α = 0.5 ω = 0.5		α = 0.5 ω = 1	
Criteria	Weight	Criteria	Weight	Criteria	Weight
Financial (P_1)	0.256	Financial (P_1))	0.265	Financial (P_1)	0.274
Customer (P_2)	0.572	Customer (P_2)	0.560	Customer (P_2)	0.548
Internal operations (P_3)	0.102	Internal operations (P_3)	0.107	Internal operations (P_3)	0.087
Company learning and growth (P_4)	0.064	Company learning and growth (P_4)	0.063	Company learning and growth (P_4)	0.062
α = 1 ω = 0		α = 1 ω = 0.5		α = 1 ω = 1	
Criteria	Weight	Criteria	Weight	Criteria	Weight
Financial (P_1)	0.271	Financial (P_1)	0.266	Financial (P_1)	0.262
Customer (P_2)	0.555	Customer (P_2)	0.560	Customer (P_2)	0.565
Internal operations (P_3)	0.102	Internal operations (P_3)	0.100	Internal operations (P_3)	0.099
Company learning and growth (P_4)	0.064	Company learning and growth (P_4)	0.065	Company learning and growth (P_4)	0.066

values of ω has been assigned to 0, 0.5, and 1.0 expressed as the pessimistic, moderate, and optimistic situation of the decision maker to observe the changes in the values of α. For a given value of ω, the relative importance weights of the criteria and sub-criteria have been calculated with varying value of α from 0 to 1. The graphs plotted with variable values of α and ω reveal the robustness and stability of the importance weights of the criteria and sub-criteria. Table 12 presents the summarized results of importance weights of the criteria for different combinations of α and ω, those are, (α=0, ω=0), (α=0, ω=0.5), (α=0, ω=1), (α=0.5, ω=0), (α=0.5, ω=0.5), (α=0.5, ω=1), (α=1, ω=0), (α=1, ω=0.5), and (α=1, ω=1).

The results from Table 12 and the corresponding graphs (Figs. 5–7) representing importance weights of criteria (BSC perspectives) for varying values of α and ω reveals that the relative importance of all the criteria (financial, customer, internal operations, and company learning and growth) has remained constant which in turn shows the robustness and stability of the findings of the present study.

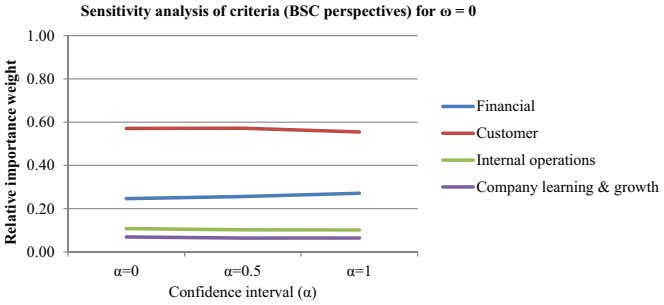

Fig. 5. Sensitivity analysis of criteria weights for ω =0.

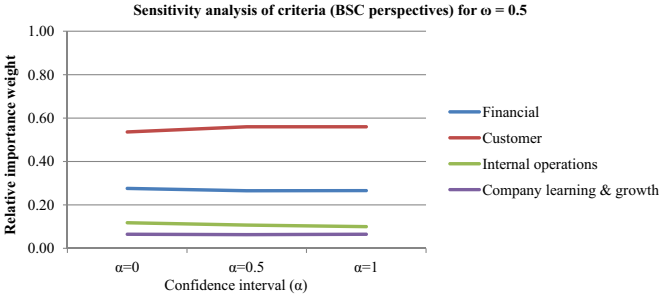

Fig. 6. Sensitivity analysis of criteria weights for ω=0.5.

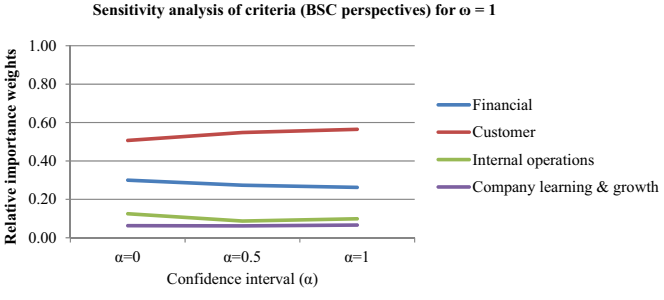

Fig. 7. Sensitivity analysis of criteria weights for ω =1.

6. Conclusions

While the focus of prior research is mostly limited to performance evaluation of manufacturing and service firms, critical evaluation of the organizational performance of a business strategy for a coal mining

organization has rarely been considered. This study attempts to reduce this gap through an empirical study measuring the short-term financial measures as well as long-term strategic objectives of the organization. The study applies BSC that substantially contributed in determining the performance indicators within each perspective as financial, customer, internal, and company learning and growth as measures of organizational performance. Deployment of FAHP facilitated in determining the relative importance weights of the identified BSC perspectives and their corresponding indicators in evaluating performance taking into consideration the subjectivity associated with the human assessment. Accordingly, a sensitivity analysis has been carried out taking into account the level of uncertainty and confidence of decision makers for prioritizing the BSC perspectives and their corresponding attributes. The study provides rationale guidance to management in analysing the suitability of organization's strategic decision of outsourcing with the organizational performance for the Indian coal mining organization. Furthermore, the entire framework has been designed and executed using Microsoft Excel® 2010 which facilitates its implementation in the organization without any additional cost to implement and to administer.

The findings primarily ascertain the significance of the BSC-FAHP approach in evaluating organizational performance associated with the outsourcing decision. The results of the present study reveal that performance indicators such as availability within customer perspective, profit variance within financial perspective, adherence to delivery schedule within customer perspective, and production target achieved within internal operations perspective are among the top priorities that need to be monitored for achieving a high level of organizational performance. Training and development, research and development within company learning and growth along with adherence to statutory norms within internal operations recede in the overall ranking and should be given due attention for sustainability and growth of the organization. The results obtained from the analysis have contributed to an in-depth understanding of a real-life problem and may act as a guiding mechanism to the mining executives in terms of decision making related to any strategic sourcing. Understanding the impact of the factors may also help management of the organization to develop policy measures accordingly.

However, there are few limitations of the present study and can be carried out in future. First, the study deals with the identification of strategic elements and their relative importance for the evaluation of organizational performance on account of an outsourcing decision, there is scope for further investigation by expanding the set of elements (indicators) within the said framework. Second, the current research work may be extended in future by incorporating the interdependent relationships (interaction effect of the indicators within and between perspectives of BSC) that have not been considered in the present study. Third, the results of the present study are based on the perceptions of a particular expert group from the Indian coal mining organization, but to enhance generalizability, the framework may be improved upon by incorporating necessary adjustments to make it applicable for other mining industries.

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