Ranking Business Scorecard Factor Using Intuitionistic Fuzzy Analytical Hierarchy Process with Fuzzy Delphi Method in Automobile Sector

S. Rajaprakash[1(✉)] and R. Ponnusamy[2]

[1] Department of Computer Science and Engineering,
Aarupadai Veedu Institute of Technology,
Vinayaka Mission University Chennai, Chennai, India
srajaprakash04@yahoo.com
[2] Department of Computer Science and Engineering,
Rajiv Gandhi College of Engineering, Chennai, India
rponnusamy@acm.in

Abstract. Business scorecard is an integral part of human resource management in an industry or an organization and used to strengthen the functionality of the organization. It plays a vital role in promoting the business. Exploring the uncertainty creeping into various factors in business scorecard is an interesting challenge. In this work, we applied Intuitionistic Fuzzy Analytical Hierarchy Process (IFAHP) with Fuzzy Delphi method to analyse the uncertainty factors in business scorecard. Also we explore the importance of various factors by means of ranking using IFAHPwith Fuzzy Delphi method. The ranking scores are further used to strengthen the business scorecard.

Keywords: Intuitionistic fuzzy analytical hierarchy process · Fuzzy delphi method · Business scorecard · Human resource management

1 Introduction

In 1965 Fuzzy sets were introduced by Lotfi A. Zadeh. A fuzzy set is a class of objects defined by a membership function. Such a set is characterised by a membership (characteristic) function which assigns to each element a grade of membership in the interval [0, 1]. Fuzzy set introduces vagueness with the aim of reducing complexity by eliminating the sharp boundary dividing the members of the pair from non-members. This mapping associates each element in a set with a certain degree of membership. It can be expressed as a discrete value or as a continuous function. In fuzzy sets, each element is mapped by the membership function. The triangular and trapezoidal membership functions are commonly used for defining continuous membership functions [1]. The triangular fuzzy membership function is given by

$$\mu_A(x) = \begin{cases} \frac{(x-a_1)}{(a_m-a_2)} : a_1 \leq x \leq a_m \\ \frac{(x-a_2)}{(a_m-a_2)} : a_m \leq x \leq a_2 \end{cases} \quad (1)$$

© Springer International Publishing Switzerland 2015
R. Prasath et al. (Eds.): MIKE 2015, LNAI 9468, pp. 437–448, 2015.
DOI: 10.1007/978-3-319-26832-3_41

$$[\mu_A(x) = \begin{cases} \frac{(x-a_1)}{(a_1^{(1)}-a_1)} : a_1 \leq x \leq a_1^{(1)} \\ 1 \qquad\qquad\quad : a_1^{(1)} \leq x a_2^{(1)} \ ] \\ \frac{(x-a_2)}{a_2^{(1)}-a_2} \quad : a_2^{(1)} \leq x \leq a_2 \end{cases} \tag{2}$$

1.1 Fuzzy Analytic Hierarchy Process (FAHP)

In 1983, Laahoven proposed the Fuzzy Analytical Hierarchy Process (FAHP) [2]. It is a combination of fuzzy set theory and Analytic Hierarchy Process. In FAHP method, the ratio of the fuzzy comparison is able to better accommodate vagueness than AHP values.

1.2 Intuitionistic Fuzzy Set (IFS)

Intuitionistic fuzzy set was introduced by Atanassov [3]. The Intuitionistic fuzzy set theory is based on fuzzy set objects and their properties. $0 \leq \pi_A(x) \leq 1$ for each $x \in X$ $\mu_A(x) \in [0,1]$ is the membership function of the fuzzy set $A^1 : \mu_{A^1}(x) \in [0,1]$ is the membership of $x \in A^1$. The intuitionistic fuzzy set is defined by

$$A = \{\langle x, \mu_x, \nu_x\rangle | x \in X\}, 0 \leq \mu_x + \nu_x \leq 1 \tag{3}$$

where $\mu_A : X \to [0,1]$ and $\nu_A : X \to [0,1]$ s.t $\mu_A(x) \in [0,1]$ denotes the membership function and $\nu_A(x) \in [0,1]$ denotes the non-membership function. Obviously $A = \{\langle x, \mu_{A^1}(x), 1-\mu_{A^1}(x)\rangle | x \in X\}$ and $\pi_A(x) = 1-(\mu_x+\nu_x)$ is called the hesitation degree or degree of nondeterminacy of $x \in A$ or $xnot \in A$. Szmidt and kacprzyk [4] point out that when calculating the distance between two IFSs, we cannot omit $\pi_A(x)$. We consider that $\alpha = (\mu_\alpha, \nu_\alpha, \pi_\alpha)$ is an intuitionistic fuzzy value where $\mu_\alpha \in [0,1]$ and $\nu_\alpha \in [0,1], \mu_\alpha + \nu_\alpha \leq 1$. According to the szmidt and kacprzyk [4] put forth a function in mathematical form

$$\rho(\alpha) = 0.5(1 + \pi_\alpha)(1 + \mu_\alpha) \tag{4}$$

The α means its contain all positive information included. Therefore intuitionistic fuzzy set mainly based on membership function and non membership function and hesitation degree.

1.3 Intuitionistic Relation

Let R be the relation in the intuitionistic values on the set $X = \{x_1, x_2 ... x_n\}$ and represented by matrix $R = (M_i^k)_{n\times n}$, where $M_{ik} = \langle (x_i, x_k), \mu(x_i, x_k), \nu(x_i, x_k)\rangle i$, $k = 1, 2, 3, \cdots, n$. Let Assume that $M_{ik} = (\mu_{ik}, \nu_{ik})$ and $\pi(x_i, x_k) = 1-\mu(x_i, x_k)-\nu(x_i, x_k)$ is interpreted as an indeterminacy degree. The notion of intuitionistic fuzzy $t-norm$ and $t-conorm$ is as found in Deschrijver *et* al. [5] The intuitionistic fuzzy triangular norms was studied by Xu [2]. He introduced the following operations:

Table 1. Comparison scale [2]

Linguistic value	Scale	Linguistic scale
9	0.9	Extreme Important
7	0.8	Very Strong Important
5	0.7	Strong Important
3	0.6	Moderately Important
1	0.5	Equal Preference
1/3	0.4	Moderately not Important
1/5	0.3	Strong not Important
1/7	0.2	Very strong not Important
1/9	0.1	Extreme not Important

1. $M_{ik} \bigoplus M_{lm} = (\mu_{ik} + \mu_{lm} - \mu_{ik}\mu_{lm}, \nu_{ik}\nu_{lm})$
2. $M_{ik} \bigotimes M_{lm} = (\mu_{ik}\mu_{lm}, \mu_{ik} + \mu_{lm} - \nu_{ik}\nu_{lm})$

In our work, we applied the Intuitionistic fuzzy AHP with Delphi method, over the business scorecard in the Auto mobile sector of India. Based on the scale given in Table 1, we are going to apply DIFAHP in the business scorecard and finally rank the factors that influences the business scorecard.

1.4 Fuzzy Delphi Method

Fuzzy Delphi method has been studies well in the literature by Kaufman and Gupta [6]. The generalization of fuzzy Delphi method is as follows:

1. Identify experts based on the domain and make the expert panel members
2. Using experts' opinion, categorize the attributes. Using the attributes, prepare the questionnaires.
3. Using the questionnaire, get the first set of the suggested attributes.
4. From the attributes, compute the mean [7]. Then deviation is calculated between mean and each expert's opinion [it is also a fuzzy number]. The deviation is sent to be each expert for re-evaluation.
5. In the second round, a new fuzzy number is received from the experts. Next, the same procedure is repeated (step-2) until two successive means become very close; else the Delphi expert will take the final decision.

2 Past Work

Satty [8] introduced the AHP approach for decision making. Atanassov [3] proposed the intuitionistic fuzzy sets and its applications. The heat produced by fans in the system can be controlled by the intuitionistic fuzzy logic approach. In this work, the heat of the fan is calculated with the help of intuitionistic

fuzzy rules applied in an inference engine using defuzzification method by Mahman akkram *et* al. [9]. The Intuitionistic fuzzy sets are used in some medical application by Eulalia Szmidt *et* al. [10]. As a generalisation of fuzzy sets, a new definition of distance between two intuitionistic fuzzy sets has been given by Atanassov by *et* al. [4]. Using the intuitionistic fuzzy analytic hierarchy process the environmental decision in the best drilling fluid(mud) for drilling operation has been by Rehan Sadiq *et* al. [11]. Rajaprakash *et* al. [12] studied the customer satisfaction in the automobile sector using the intuitionistic fuzzy analytic hierarchy process. Yen cheng chen *et* al. [13] studied the hotel and atmosphere usage using Delphi fuzzy Analytical Hierarchy Process in two phases: the first one by the Delphi method and the second one by AHP. The selection of best DBMS among several candidates in the Turikish National Identity Card Management project was done using the Fuzzy AHP by F.Ozgur Catak *et* al. [14]. The Fuzzy AHP evaluation of the E-commerce in order manage and determine the drawbacks and opportunities was studied by Feng Kong *et* al. [15] Mohammad Izadikhah [16] studied the supplier selection problem under incomplete and uncertain information environment using TOPSIS Method. The prediction of highest and lowest temperature by back propagation neural networks training for abnormal weather alerts has been studied by a fuzzy AHP and rough set. In this work, we compared the fuzzy AHP and rough set as guided by Dan Wang *et* al. [7] using the FAHP students expectation in the present education system in Tamilnadu, India. Fuzzy Delphi Method and Fuzzy Analytic Hierarchy process is applied to determine the critical factors of the regenerative technologies and to find the degree of each important criterion as the measurable indices of the regenerative technologies proposed by Yu-Lung Hsu *et* al. [17] Lazim Abdullah *et* al. [18] have been studied the human capital indicator and ranking by using IFAHP to evaluate the four main indicators of human capital. Diagnosis progress in bacillus colonies identification in the medical domain using the intuitionistic fuzzy set theory has been studied by Hoda Davarzani *et* al. [18] The preference of Customer requirement factors in automobile sector using IFAHP with delphi method was studied by s.Rajaprakash *et* al. [19] Intuitionistic Fuzzy Delphi Method is used as forecasting tool based on experts suggestion. Tapan Kumar *et* al. [20] have used triangular fuzzy numbers and aggregated based on the opinion of the experts.

3 Methodology

1. Based on the requirements, expert panel was formed. In our work, we are used 10 experts for Delphi Method.
2. Based on the suggestions of the experts, the values are converted into intuitionistic value (comparison scale Table 4 and then the construction of the comparison matrix is carried out.
3. According to Xu *et* al. [21], check the consistency of the matrix intuitionistic preference relations as given below:

$R = (M_{ik})_{n\times n}$ with $M_{ik} = (\mu_{ik}, \nu ik)$ is multiplicative consistent if

$$\mu_{ik} = \begin{cases} 0 & if(\mu_{it}, \mu_{tk}) \in \{(0,1),(1,0)\} \\ \frac{\mu_{it}\mu_{tk}}{\mu_{it}+\mu_{tk}+(1-\mu_{it})(1-\mu_{tk})} & otherwise \end{cases} \tag{5}$$

$$\nu_{ik} = \begin{cases} 0 & if(\nu_{it}, \nu_{tk}) \in \{(0,1),(1,0)\} \\ \frac{\nu_{it}\nu_{tk}}{\nu_{it}+\nu_{tk}+(1-\nu_{it})(1-\nu_{tk})} & otherwise \end{cases} \tag{6}$$

In the fuzzy preference relation, the following statements are equivalent: [21]

$$b_{ik} = \frac{b_{ik}b_{tk}}{b_{ik}b_{tk} + (1-b_{ik})(1-b_{tk})} \; i,t,k = 1,2,3... \tag{7}$$

$$b_{ik} = \frac{\sqrt[n]{\prod_{s=1}^{n} b_{ik}b_{tk}}}{\sqrt[n]{\prod_{s=1}^{n} b_{is}b_{sk}} + \sqrt[n]{\prod_{s=1}^{n} b_{is}b_{sk}}} \; i,k = 1,2,...n \tag{8}$$

$$\bar{\mu}_{ik} = \frac{\sqrt[k-i-1]{\prod_{t=i+1}^{k-1} \mu_{it}\mu_{tk}}}{\sqrt[k-i-1]{\prod_{t=i+1}^{k-1} \mu_{it}\mu_{tk}}} \; k > i+1 \tag{9}$$

$$\bar{\nu}_{ik} = \frac{\sqrt[k-i-1]{\prod_{t=i+1}^{k-1} \nu_{it}\nu_{tk}}}{\sqrt[k-i-1]{\prod_{t=i+1}^{k-1} \nu_{it}\nu_{tk}}} \; k > i+1 \tag{10}$$

4. The distance between intuitionistic relations [4] is calculated using

$$d(M,\bar{M}) = \frac{1}{2(n-1)(n-2)} \sum_{t=1}^{n}\sum_{k=1}^{n}(|\bar{\mu}_{ik}-\mu_{ik}|+|\bar{\nu}_{ik}-\nu_{ik}|+|\bar{\pi}_{ik}-\pi_{ik}|) \tag{11}$$

5. The priority of the intitionistic preference relation is calculated by the following method suggested by Zeshuri Xu [21]:

$$W_i = \frac{\sum_{k=1}^{n} M_{ik}^1}{\sum_{i=1}^{n}\sum_{k=1}^{n} M_{ik}^1}$$

$$W_i = \left[\frac{\sum_{k=1}^{n} \mu_{ik}}{\sum_{i=1}^{n}\sum_{k=1}^{n}[1-\nu_{ik}]}, 1 - \frac{\sum_{k=1}^{n}[1-\nu_{ik}]}{\sum_{i=1}^{n}\sum_{k=1}^{n}\mu_{ik}}\right] \tag{12}$$

6. After finding weights of all levels, perform ranking of the weights by using the formula (4); then find preference ranking.

4 Illustrative Work

The above work illustrated in the areas of business scorecard of Human Resource Management department in the automobile sector at Chennai. Here, we are ranking the factors of the business scorecard using the above method. In this work, the data were collected from the car manufacturing company.

4.1 Observation from the Experts

Based on the observation from the experts, the business score card is used to promote the business and its future requirements via formulating the critical needs of the business with meticulously framed metrics to cater their clients in the most efficient way as well as coping up with the latest technologies. The important factors are Profit, Growth, People, and Reputation. This process is adopted half yearly once for effective monitoring and implementation. The hierarchy is based on the experts' suggestion as shown in the Fig. 1.

4.1.1 Profit: The employees should adjust their expenses and head count according to the sales and profits they generated. Here we are classified this into three factors: Increase or maintain shareholder return, maintain projected revenue growth and collections, maintain projected efficiency in the use of fixed and variables.

1. Main shareholder return: Actual requirements is identified and the Key Research Area (KRA) has been fixed to develop the same, when this has been successfully implemented. Then the shareholders will invest further into the business for multiplying their investments.
2. Maintain projected revenue growth: The business score cards help to attain the projected growth in terms of revenue at the start up of the project with their will defined KRA's.
3. Maintain projected efficiency in use of fixed and variable: The fixed and variable assets have to be efficiently utilised to achieve the projected target.

4.1.2 Growth: The organization should work for the business growth by understanding the business goals and requirement, fitting into their Key Resource Areas and identify the Key Result Areas as well. The three important factors to grow up are: improve material yield, improve Value Added Per Employee (VAPE), improve Value Added Per Employee Cost (VAPEC).

1. Improve VAPE: The merits and calculations help to identify per employee value addition to the business. It is a detailed study of the contributions by every employee.
2. Improve VAPEC: It is a calculation which helps to the organization to identify the return earned through each individual employee. It is based on the actual factors like sales and plan.

4.1.3 People: The HR Department should work for the development of their people and welfare through conducting various Employee Engagement Activities. Here we have three important attributes: Welfare, Employee Engagement and Salary

1. Welfare: It is the process of providing the employees all facilities and amenities in order to work in the organisation with an effective output.
2. Employee Engagement: It is the process of bring up all employees together and involving them in one agenda there by creating an atmosphere of one culture with one goal. It helps retention of employee in an organisation.
3. Salary: It is the main key of motivation for an employee. It is fixed based on the merits of the employee in terms of his education experience and skill level as will in accord with ovaries trend.

4.1.4 Reputation: The organization should identify the potential of the business and manage the latest technology and competition thereby, bringing in competitive products, people and price as well contributing to the brand building of the organization.

1. Vision and Mission: The organization will have their own preformed principles vision as mission in which the company wants to excel and reinforce that all their employees should follow. This principal will make the organisation to grow up further.
2. Culture and Values: The climate of the organisation has to pleasantly maintained, which is possible only when the organization sets its own professional environment with value, ethics and cultures.
3. Organisation Transformation: This is a process of adapting and adjusting according to the changing environment, technologies by bring in a lot of new innovative and creative ideas to develop the organisation. It is only a source to withstand the demand and expectations of the clients in the present scenario.

4.2 Business Scorecard in Level-1

In order to find the business scorecard in level-1, four attributes are available. Based on the experts' opinion, the first initial Table 2 has been formed.

The mean values are calculated. The deviations of experts' opinion from the calculated mean values are given below Table 3.

Here the Delphi experts are not satisfied with the deviation Table 3. Therefore, opinion is sent back to the experts for one more opinion.

The deviation from the mean is calculated as given in Table 5.

Now the Delphi expert is satisfied with the above deviation Table 5. Based on the expert suggestion, the first intuitionistic preference relation matrix for the business scorecard is formed as shown below:

$$M = \begin{pmatrix} (0.5, 0.5) & (0.5, 0.4) & (0.4, 0.6) & (0.5, 0.6) \\ (0.7, 0.3) & (0.5, 0.5) & (0.5, 0.4) & (0.5, 0.5) \\ (0.5, 0.4) & (0.5, 0.4) & (0.5, 0.5) & (0.4, 0.5) \\ (0.6, 0.4) & (0.6, 0.4) & (0.5, 0.4) & (0.5, 0.5) \end{pmatrix}$$

check the consistence preference relations using the above formula (9) and (10), we can get the multiplicative fuzzy relation Matrix($\bar{M}$).

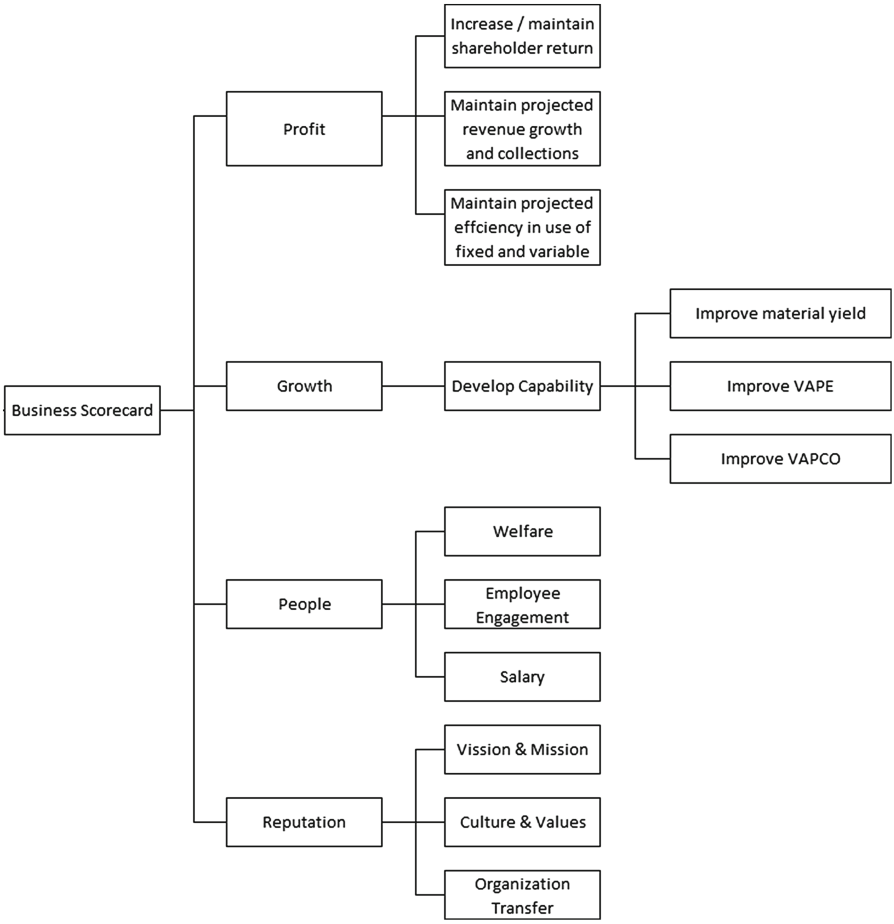

Fig. 1. Business scorecard - hierarchy

$$\bar{M} = \begin{pmatrix} (0.5, 0.5) & (0.5, 0.4) & (0.4494, 0.5) & (0.4, 0.51) \\ (0.6, 0.5) & (0.5, 0.5) & (0.5, 0.4) & (0.5025, 0.4449) \\ (0.5, 0.449) & (0.4, 0.5) & (0.5, 0.5) & (0.4, 0.5) \\ (0.5, 0.4) & (0.449, 0.50254) & (0.5, 0.4) & (0.5, 0.5) \end{pmatrix}$$

Then using the Eq. (11), the distance between intuitionistic relation is calculated as $d(\bar{M}, M) = 0.09578$ which is less than τ. Here, we will fix the threshold value as $\tau = 0.1$. Therefore, the above matrix is consistent. The next step is calculating the weight of all attributes using the Eq. (12). It is given in Table 6 and using the Eq. (4), we will get the preference(P) of all attributes. It is given in Table 7. We can see that the first preference is quality, second is delivery, third is cost, and last one is service. Similarly we calculated the weights for other levels.

Table 2. Delphi 1

Experts	BS1 to BS2		BS1 to BS3		BS1 to BS4		BS2 to BS3		BS2 to BS4		BS3 to BS4	
1	0.5	0.4	0.4	0.2	0.6	0.3	0.4	0.3	0.5	0.3	0.6	0.4
2	0.6	0.3	0.5	0.3	0.5	0.4	0.3	0.4	0.7	0.3	0.6	0.4
3	0.7	0.3	0.3	0.2	0.5	0.3	0.5	0.3	0.5	0.5	0.5	0.6
4	0.3	0.6	0.6	0.3	0.6	0.3	0.4	0.4	0.5	0.4	0.7	0.4
5	0.4	0.5	0.2	0.3	0.3	0.6	0.5	0.5	0.6	0.4	0.5	0.4
6	0.5	0.4	0.3	0.4	0.5	0.5	0.6	0.4	0.3	0.5	0.6	0.5
7	0.6	0.3	0.4	0.2	0.5	0.4	0.7	0.3	0.5	0.4	0.5	0.6
8	0.7	0.2	0.3	0.3	0.6	0.5	0.3	0.4	0.6	0.4	0.6	0.4
9	0.5	0.4	0.2	0.5	0.4	0.4	0.5	0.5	0.7	0.4	0.4	0.5
10	0.4	0.5	0.7	0.3	0.3	0.6	0.5	0.2	0.6	0.4	0.5	0.6

Table 3. Delphi2

Experts	BS1 to BS2		BS1 to BS3		BS1 to BS4		BS2 to BS3		BS2 to BS4		BS3 to BS4	
1	0.02	−0.01	−0.01	0.1	−0.12	0.13	0.07	0.07	0.05	0.1	−0.05	0.08
2	−0.08	0.09	−0.11	0	−0.02	0.03	0.17	−0.03	−0.15	0.1	−0.05	0.08
3	−0.18	0.09	0.09	0.1	−0.02	0.13	−0.03	0.07	0.05	−0.1	0.05	−0.12
4	0.22	−0.21	−0.21	0	−0.12	0.13	0.07	−0.03	0.05	0	-0.15	0.08
5	0.12	−0.11	0.19	0	0.18	−0.17	−0.03	−0.13	−0.05	0	0.05	0.08
6	0.02	−0.01	0.09	−0.1	−0.02	−0.07	−0.13	−0.03	0.25	−0.1	−0.05	−0.02
7	−0.08	0.09	−0.01	0.1	−0.02	0.03	−0.23	0.07	0.05	0	0.05	−0.12
8	−0.18	0.19	0.09	0	−0.12	−0.07	0.17	−0.03	−0.05	0	−0.05	0.08
9	0.12	−0.11	−0.31	0	0.18	−0.17	−0.03	0.17	−0.05	0	0.05	−0.12
10	0.12	−0.11	−0.31	0	0.18	−0.17	−0.03	0.17	−0.05	0	0.05	−0.12

5 Empirical Result

Based on the suggestions given by the experts of the business scorecard hierarchy is formed in Level-1. Four attributes (factors) are ranked (Table 7) as follows: Profit, Growth, People and, Reputation of the organization. In the Level-2, the key attribute of the industry is Profit which is based on three factors and its ranked as follows: Increase or Maintain Shareholder return,Maintain Projected efficiency is use of fixed and variable and Maintain Projected revenue growth and collection. The next attribute is growth of the industry. It is mainly classified in to three factors and its ranked as follows: improve material yield, improve VAPCO and Improve VAPE. The next attribute is People. It have three factors and its ranked as follows: welfare, salary, employment engagement. The last Attribute is reputation, it has three main attributes and its raked as follows: Vision and Mission, Organisation Transfer and Culture and values. Therefore,

Table 4. Delphi3

Experts	BS1 to BS2		BS1 to BS3		BS1 to BS4		BS2 to BS3		BS2 to BS4		BS3 to BS4	
1	0.6	0.4	0.4	0.4	0.6	0.3	0.4	0.4	0.52	0.5	0.3	0.5
2	0.6	0.4	0.3	0.5	0.6	0.4	0.4	0.4	0.6	0.6	0.4	0.4
3	0.5	0.4	0.6	0.2	0.6	0.2	0.5	0.4	0.4	0.4	0.4	0.6
4	0.6	0.6	0.4	0.4	0.6	0.3	0.4	0.4	0.6	0.4	0.4	0.6
5	0.6	0.4	0.5	0.4	0.5	0.6	0.5	0.5	0.5	0.5	0.3	0.6
6	0.4	0.2	0.4	0.4	0.5	0.5	0.6	0.4	0.6	0.5	0.5	0.4
7	0.6	0.4	0.4	0.4	0.5	0.4	0.7	0.3	0.5	0.5	0.4	0.3
8	0.4	0.4	0.5	0.5	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5
9	0.4	0.4	0.3	0.4	0.4	0.4	0.6	0.4	0.4	0.5	0.4	0.6
10	0.5	0.5	0.4	0.3	0.4	0.5	0.5	0.4	0.4	0.6	0.5	0.4

Table 5. Delphi4

Experts	BS1 to BS2		BS1 to BS3		BS1 to BS4		BS2 to BS3		BS2 to BS4		BS3 to BS4	
1	−0.08	0.01	0.02	−0.01	−0.09	0.1	0.1	0	−0.01	0 0.11	−0.01	0
2	−0.08	0.01	0.12	−0.11	−0.09	0	0.1	0	−0.098	−0.1	0.01	0.09
3	0.02	0.01	−0.18	0.19	−0.09	0.2	0	0	0.102	0.1	0.01	−0.11
4	-0.08	−0.19	0.02	−0.01	−0.09	0.1	0.1	0	−0.098	0.1	0.01	−0.11
5	−0.08	0.01	−0.08	−0.01	0.01	−0.2	0	−0.1	0.002	0	0.11	−0.11
6	0.12	0.21	0.02	−0.01	0.01	−0.1	−0.1	0	−0.098	0	−0.09	0.09
7	−0.08	0.01	0.02	−0.01	0.01	0	−0.2	0.1	0.002	0	0.01	0.19
80	.12	0.01	−0.08	−0.11	0.11	0	0.1	0	0.002	0	−0.09	−0.01
90	.12	0.01	0.12	−0.01	0.11	0	−0.1	0	0.102	0	0.01	−0.11
10	0.02	−0.09	0.02	0.09	0.11	−0.1	0	0	0.102	−0.1	−0.09	0.09

Table 6. Weight

weight	μ	ν
W(BS1)	0.21763	0.72733
W(BS2)	0.2474	0.702077
W(BS3)	0.2118	0.73375
W(BS4)	0.22939	0.71467

Table 7. Rank

Attribute	$\rho(\alpha)$	P
Profit(PS1)	0.88958	1
Growth(PS2)	0.85299	2
People(PS3)	0.852624	3
Reputation(PS4)	0.840044	4

from the value $\rho(\alpha)$ and Tables and Diagrams, we can get the preference ranking of the attribute of the automobile sector using the IFAHP Fuzzy Delphi method.

6 Conclusion

In this work, we combine Intiutionistic Fuzzy Analytical Hierarchy Process and Fuzzy Delphi Method to analyse the business scorecard in the automobile sector in India. The Major part of IFAHP With Fuzzy Delphi Method include the following. In Delphi Method, questionnaires were framed based on the suggestions and opinions obtained from the experts in the automobile sector. In this work, we are categories the business scorecard. At each and every level, we rank the (preference) factors of business scorecard. The major disadvantage of our work is in identifying the experts and getting opinions from them will take a huge amount of time. The outcome is useful for the automobile sector and it may improve the industrial standard and economy of the company.

References

1. Klir, G.J.: Fuzzy Set and Fuzzy Logic Theory and Application. PTR Publisher, New York (1995)
2. Xu, Z., Liao, H.: Intuitionistic fuzzy analytic hierarchy process. IEEE Trans. Fuzzy Syst. **22**(4), 749–761 (2014)
3. Atanassov, K.T.: Intuitionistic fuzzy sets. Fuzzy Sets Syst. **20**(1), 87–96 (1986)
4. Szmidt, E., Kacprzyk, J.: Distances between intuitionistic fuzzy sets. Fuzzy Sets Syst. **114**(3), 505–518 (2000)
5. Deschrijver, G., Cornelis, C., Kerre, E.: On the representation of intuitionistic fuzzy t-norms and t-conorms. Notes Intuit. Fuzzy Sets **8**(3), 1–10 (2002)
6. Kaufmann, A., Gupta, M.M.: Fuzzy Mathematical Models in Engineering and Management Science. Elsevier Science Inc., New York (1988)
7. Carlsson, C., Fullr, R.: On possibilistic mean value and variance of fuzzy numbers. Fuzzy Sets Syst. **122**(2), 315–326 (2001)
8. Saaty, T.: The Analytic Hierarchy Process, Planning, Priority Setting, Resource Allocation. McGraw-Hill, New york (1980)
9. Akram, M., Shahzad, S., Butt, A., Khaliq, A.: Intuitionistic fuzzy logic control for heater fans. Math. Comput. Sci. **7**(3), 367–378 (2013)
10. Szmidt, E., Kacprzyk, J.: Intuitionistic fuzzy sets in some medical applications. In: Reusch, B. (ed.) Fuzzy Days 2001. LNCS, vol. 2206, pp. 148–151. Springer, Heidelberg (2001)
11. Sadiq, R., Tesfamariam, S.: Environmental decision-making under uncertainty using intuitionistic fuzzy analytic hierarchy process (IF-AHP). Stoch. Env. Res. Risk Assess. **23**, 75–91 (2009)
12. Rajaprakash, S., Ponnusamy, R., Pandurangan, J.: Determining the customer satisfaction in automobile sector using the intuitionistic fuzzy analytical hierarchy process. In: Prasath, R., O'Reilly, P., Kathirvalavakumar, T. (eds.) MIKE 2014. LNCS, vol. 8891, pp. 239–255. Springer, Heidelberg (2014)
13. Chen, Y.C., Yu, T.H., Tsui, P.L., Lee, C.S.: A fuzzy AHP approach to construct international hotel spa atmosphere evaluation model. Qual. Quant. **48**(2), 645–657 (2014)
14. Catak, F.O., Karabas, S., Yildirim, S.: Fuzzy analytic hierarchy based DBMS selection in turkish national identity card management project. Int. J. Inf. Sci. Tech. (IJIST) **2**(4), 29–38 (2012)

15. Kong, F., Liu, H.: Applying fuzzy analytic hierarchy process to evaluate success factors of e-commerce. Int. J. Inf. Syst. Sci. **1**(3), 406–412 (2005)
16. Izadikhah, M.: Group decision making process for supplier selection with topsis method under interval-valued intuitionistic fuzzy numbers. Adv. Fuzzy Sys. **2012**, 1 (2012)
17. Hsu, Y.L., Lee, C.H., Kreng, V.B.: The application of fuzzy delphi method and fuzzy ahp in lubricant regenerative technology selection. Expert Syst. Appl. **37**(1), 419–425 (2010)
18. Abdullah, L., Jaafar, S., Taib, I.: Intuitionistic fuzzy analytic hierarchy process approach in ranking of human capital indicators. J. Appl. Sci. **13**(3), 423–429 (2013)
19. S.Rajaprakash, R.ponnusamy, J.: Intuitionistic fuzzy analytical hierarchy process with fuzzy delphi method. Global journal of pure and applied mathematics (3) (2015) 1677–1697
20. Roy, T.K., Garai, A.: Intuitionistic fuzzy delphi method: More realistic and interactive forecasting tool. Notes Intuit. Fuzzy Sets **18**(50), 37–50 (2012)
21. Xu, Z.: Intuitionistic preference relations and their application in group decision making. Inf. Sci. **177**(11), 2363–2379 (2007)