Determining the Balance Scorecard in Sheet Metal Industry Using the Intuitionistic Fuzzy Analytical Hierarchy Process with Fuzzy Delphi Method

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Abstract. Balance Scorecard (BS) is an important part of human resource management in any organization or industry. It used to cascade the organization vision and its expectation and develop the employment capability. Balance scorecard may have many factors. In order to produce the best product and to retain the trust of customers, the industry should be able to identify which area has to be concentrated with higher priority in the Balance Scorecard. This situation lead with an uncertainty to multi criteria decision making. In this work, an attempt has been made for ranking the factors in the Balance Scorecard using Intuitionistic fuzzy analytical hierarchy process with fuzzy Delphi method.

Keywords: Intuitionistic fuzzy analytical hierarchy process · Analytical Hierarchy Process · Human resource

1 Introduction

A fuzzy set introduced by Zadeh (1965) defines a set characterized by a membership function. A membership function assigns to each element in the set under consideration a membership grade which is a value in the interval [0,1]. It was specifically designed to represent uncertainty and vagueness and to provide for normalized tools for dealing with the imprecision in intrinsic to many problems.

Fuzzy set introduces vagueness with the aim of reducing complexity by eliminating the sharp boundary dividing the members of the pair from

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non-members. This mapping associates each element in the set with its degree of membership. It can be expressed as a discrete value or as a continuous function. In fuzzy sets, each element is mapped by its membership function. They are triangular and trapezoidal membership functions that are commonly used for defining the continuous membership functions [1].

The triangular fuzzy membership function is given by

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

and the trapezoidal fuzzy membership function is given by

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

1.1 Fuzzy Analytic Hierarchy Process (FAHP)

The Analytic Hierarchy Process (AHP) is one of the Fuzzy Multiple Criteria Decision Making methods. In 1983, Laahoven proposed the Fuzzy Analytical Hierarchy Process (FHAP). It is a combination of fuzzy set theory and Analytic Hierarchy Process. The application of FAHP is still flourishing. In this method, the ratio of the fuzzy comparison are able to better accommodate of vagueness comparing to AHP in which crisp value are used.

1.2 Intuitionistic Fuzzy Set (IFS)

Intuitionistic fuzzy set introduced by Atanassov [2]. The Intuitionistic fuzzy set theory is based on fuzzy set object and new 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 defined by

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

where $\mu_A : X \rightarrow [0,1]$ and $\nu_A : X \rightarrow [0,1]$ s.t $\mu_A(x) \in [0,1]$ denote the membership function and $\nu_A(x) \in [0,1]$ denote 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 non-determinacy of $x \in Aorxnot \in A$. Szmidt and Kacprzyk [3] point out that when calculating the distance between two IFSs, we can not omit $\pi_A(x)$. We consider that $\alpha = (\mu_\alpha, \nu_\alpha, \pi_\alpha)$ is an intuitionistic fuzzy values where $\mu_\alpha \in [0,1]$ and $\nu_\alpha \in [0,1], \mu_\alpha + \nu_\alpha \leq 1$. According to the Szmidt and Kacprzyk [3] put forth a function in mathematical form

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

The α means that it contains all positive information included. Therefore intuitionistic fuzzy set is mainly based on the membership function, the non-membership function, and the indeterminacy degree.

Table 1. Comparison scale [4]

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

1.3 Intuitionistic Relation

Let R be the relation in the intuitionistic values on the set $X = \{x_1, x_2 ... x_n\}$ is 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 us 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 [4]. He introduced the following operations

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 are applying the Intuitionistic Fuzzy AHP with Delphi method, over the balance scorecard in Auto Sheet Metal Industry, India. Based on the above scale, Table 1 shows the comparison matrix with the ranked list of factors.

1.4 Fuzzy Delphi Method

Kaufman and Gupta [6] have studied about the Fuzzy Delphi Method. In 1993, Ishikawa *et* al. [7] also mention about the Fuzzy Delphi Method. The generalization of fuzzy Delphi method is as follows:

1. Identify the experts based on the domain and make the experts panel members
2. Based on the experts opinion identify the attributes and categories. Using the attributes make the questionnaires.
3. Using the questionnaires gets the first round of the suggestion about the attributes.
4. From the attributes values compute the Mean. [8] Then deviation is calculated between mean and each expert opinion. [it is also a fuzzy number]. The deviation is sent to each expert for revaluation.

5. In the second round a new fuzzy number is received from the experts. The same procedure is repeated (step-2) until two successive means become very close; else the Delphi expert will take the final decision.

2 Literary Survey

Satty [9] introduced the AHP approach for decision making. Atanassov [2] proposed the intuitionistic fuzzy sets and its applications. Mahman Akkram *et* al. [10] proposed an approach to control the heat produced by fans using the Intuitionistic fuzzy logic. 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. The Intuitionistic fuzzy sets are used in some medical application by Eulalia Szmidt *et* al. [11]. As a generalization of fuzzy sets, a new definition of distance between two intuitionistic fuzzy sets has been suggested by Atanassov *et* al. [3].

Rehan Sadiq *et* al. [12] proposed the intuitionistic fuzzy analytic hierarchy process to make the environmental decision making process easier. In this work, authors find the best drilling operation in the fluid(mud). Determining the customer satisfaction in the automobile sector, the Intuitionistic fuzzy analytic hierarchy process has been studied by Rajaprakash *et* al. [13]. To increase the hotel atmospheres and its environment, use of Delphi fuzzy Analytical Hierarchy Process ranking the customer preference in spa atmosphere has been studied in two phases: the first one is Delphi method and the second one is by AHP, by Yen Cheng Chen *et* al. [14]. The selection of the best DBMS among the several candidates in the Turkish National Identity Card Management project was done using the Fuzzy AHP by F. Ozgur Catak *et* al. [15]. Using the Fuzzy AHP evaluation of the E-commerce in order to manage and determine the drawbacks, opportunities were studied by Feng Kong *et* al. [21]. The supplier selection is typically a multi criteria decision problem. Ranking the similarity to ideal solution (TOPSIS) method for group decision making with intuitionistic fuzzy numbers is proposed by Mohammad Izadikhah [16]. The prediction of the highest and the lowest temperature by BP neural networks training for abnormal weather alerts have been studied by Dan Wang *et* al. [8] using a fuzzy AHP and rough set. In this work, authors compared the fuzzy AHP and rough set.

The expectation of students in the present education system in Tamilnadu, India has been studied using the FAHP. In the work, Rajaprakash *et* al. [17] have taken a sample work on Engineering education. The Fuzzy Delphi Method and Fuzzy analytic Hierarchy process have been applied to determine the critical factors of the regenerative technologies and find the degree of each importance criterion as the measurable indices of the regenerative technologies. This work was attempted by Yu-Lung Hsu *et* al. [7]. The study of human capital indicator and ranking by using IFAHP to evaluate the four main indicators of Human capital has been studied by Lazim Abdullah *et* al. [18]. Diagnosis progress in bacillus colonies identification in the medical field using the intuitionistic fuzzy set theory studied by Hoda davarzani *et* al. [18]. Intuitionistic Fuzzy Delphi

Method used as forecasting tool based on the suggestion of the experts in the work proposed by Tapan Kumar *et* al. [19]. They used triangular fuzzy number and aggregation process based on the opinion of the experts.

3 Methodology

1. Using the fuzzy Delphi method experts, values are converted to Intuitionistic value and make the comparison matrix (comparison scale Table 4).
2. To the check the consistent of the matrix intuitionistic preference relation calculated based on Xu *et* al. [20] which is given below
   $R = (M_{ik})_{n\times n}$ with $M_{ik} = (\mu_{ik}, \nu ik)$ is multiplicative consistent if

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

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

   Theorem [20]**:** In fuzzy preference relation, the following statement are equivalent:

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

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

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

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

3. The distance between intuitionistic relation [3] is calculated using

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

4. The priority of the intuitionistic preference relation zeshuri Xu [20] is calculated by the following method.

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

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

5. After finding the weights of the all levels based on weights (ranking the weight) by using the Eq. 4 then finding preference ranking.

4 Illustrative Work

The above work illustrated in area of the balance scorecard of human resource in the automobile sector sheet metal industry at Chennai. Balanced Scorecard is classified into various factors based on the experts opinion. Here we are ranking the factor of Balanced Scorecard using the above method. In this work, the data collected from sheet metal industry.

4.1 Balance Scorecard

The balanced scorecard revolutionized conventional thinking about performance metrics. In 1992 Kaplan and Norton first introduced the concept. The scorecard allowed companies to track financial results while monitoring progress in building the capabilities needed for growth. It is used to strengthen the Key Resource Area's (KRA) and Key performance Indicator's (KPI'S) of every individual which helps for higher productivity, cost efficiency, effective utilization of machine and man and method. Balance scorecard are categorised into four important attributes like Financial, Customer, Internal Process, Learning and growth in level-1. In level-2, each attributes divided into sub attributes.

4.2 Finance

Based on the observation from the experts the Balance 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 factor are like Profit, Growth, People and Reputation. The process is adopted half yearly for effective monitoring and implementation.

How effective the people are utilized. How effective the assets fixed and variable has been utilized and handled. If all the above points have been used then organization achieves the best revenue in business.

4.2.1 Achieve Total Revenue of Business

1. It is based on the following queries.
2. What should be the sales number of the current year?
3. What should be the manpower head count bared on the sales?

4. What should be the welfare expenses bared on the sales as well manpower head count?
5. What are the effective ways to control the cost?
6. What kind of economic cost effective automatons has to be brought in?
7. How much number of Kaizens has to be evolved?
8. How well the plant maintenance has to be adopted?

4.2.2 Collecting the Overdue Debits

The finance department of the organization has to separate the good and bad vendors. Accordingly the debits can also been categorized as immediate receivables with regulars intervals, recovered only after regular follow up, recovered when only any employees goes on personal visits. In short, the organization has to fix its price according to their rate of return to overcome the loss in overdue debits.

4.2.3 Achieve the Targeted Rate of Return

To achieve the targeted rate of return, the organization should focus on the achieving the total revenue of the business, collecting the overdue debits, as well targeting on its employee productivity. In short, it has to booze up the Man Method and the machines.

4.2.4 Inventory Turnover

The organization has to concentrate on its inventory to have a control on it. It is also helps in huge cost reduction, the success of maintain inventory lies in how many times the inventory has been turnover, and how much cost has been saved. The art of managing inventory lies in keeping the minimal stock by avoiding ageing of inventory and efficiently managing by effective utilization of the factory. Generally the inventory turnover formula is average is stock and number of days in month divided by sales.

The main support for inventory monitoring is the stores department. The store will depict the assessment of inventories. If the stores have been monitored well with the options of labeling, arranging a proper accessing enables the success of efficient inventory turnover.

4.3 Customer

The customer is the important role in the sheet metal industry, here customer satisfaction and customer requirement are very important part in Business Scorecard. When the customer relationship is honored and the industry can get a new Business, which reflects the overall branding of the industry. Customer relationship include many factors like quality, delivery, commercial dealing, product quality, response to queries, concern of problem etc. So based on the many factors customer relationship honoured Rajaprakash *et* al. [13]. The customer requirement is based on the many factor like Quality, Cost,

Delivery, and service, Supplier request for Engineering change approval(SREA), Emergency Response action(ERA), Corrective action and Preventive action taken(CA and PA) and so on, Similarly Based on the customer requirement and satisfaction a matrix has been framed it is known as customer matrix. Thus from the customer matrix we know the clear picture of the customer. If the customer satisfaction is honoured then the industry can get the new business.

4.4 Internal Process

The internal process is the main back none for the success of the organization business. The internal process is decided by improved material, Improve VAPE and PPM set by customer plant maintenance, Tier II development and 2s safety.

4.4.1 Improve Material

The material consumption has to be followed properly and rigorously for the success of the business. The material planning is the vital role of the organization. The material planning team has to keep constant touch with the production planning team to anticipate the production fluctuating and ramp up. This coordination will help to keep the material stock in control as well to produce the emergency material which can create a crisis situation in the shop floor. This kind of planning always helps the last hour rushing as well avoiding freight cost which normally occurs and business the EBITA.

4.4.2 Improve VAPE

The value addition per employee is the main factor or calculative method which helps to calculate and control the employee recruitment cost and their effectiveness monitoring in the organization in the sense how the new employee or the exiting employee contributes in regards with their cost to company the VAPE is calculated as follows. VAPE is equal to value added divided by number of employees. It is decided and directly proportional to the VAPCO. The VAPCO is derived with value addition per employee cost. VAPCO is equal to value added per manpower cost. The value added is equal to sales − (raw material cost + Job work + VAPE). Manpower cost equal to regular + contract worker + staff welfare. It is basically used to calculate the head count of the employees with its sales and to benchmark the best of the head count required. It will be further fine tuned by required continuous manpower optimization with proper job description, work allocation, work planning and so on.

4.4.3 PPM Set by Customer

The PPM will be set by customer and it has to be followed in reward with quality and target has to be fixed for it. The PPM has to continuously monitored by internal and external quality circle.

4.4.4 Plant Maintenance

The plant has to be maintained in its regular manner. Generally the idea is production industry is the shop floor depicts the organization technology values and principles. The plant is well maintained by various initiates like 5s, TPM, etc. The well maintained plant always reflects high productivity and high morale.

4.4.5 2s and Safety

The 2s safety has to be maintained strictly since there in no compromise on safety otherwise it is zero tolerance with safety. The 2s helps the operator to finish his task sap as well the tools will be fixed and available in the required slot. It will reduce the time loss and save the energy of the operator.

4.5 Learning and Growth

The HR Department should work for the development of their people and welfare through conducting various Employee Engagement Activities. 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 Fig. 1.

4.6 Business Scorecard in Level-1

In order to find the Balance Scorecard in Level-1 four attributes are available. Based on the experts opinion the first initial Table 2 formed

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

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

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

Now the Delphi expert is satisfied with the above deviation Table 5. Based on the expert suggestion the first intuitionistic preference relation matrix BS formed is shown below.

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

The deviation from the mean is calculated Table 5.

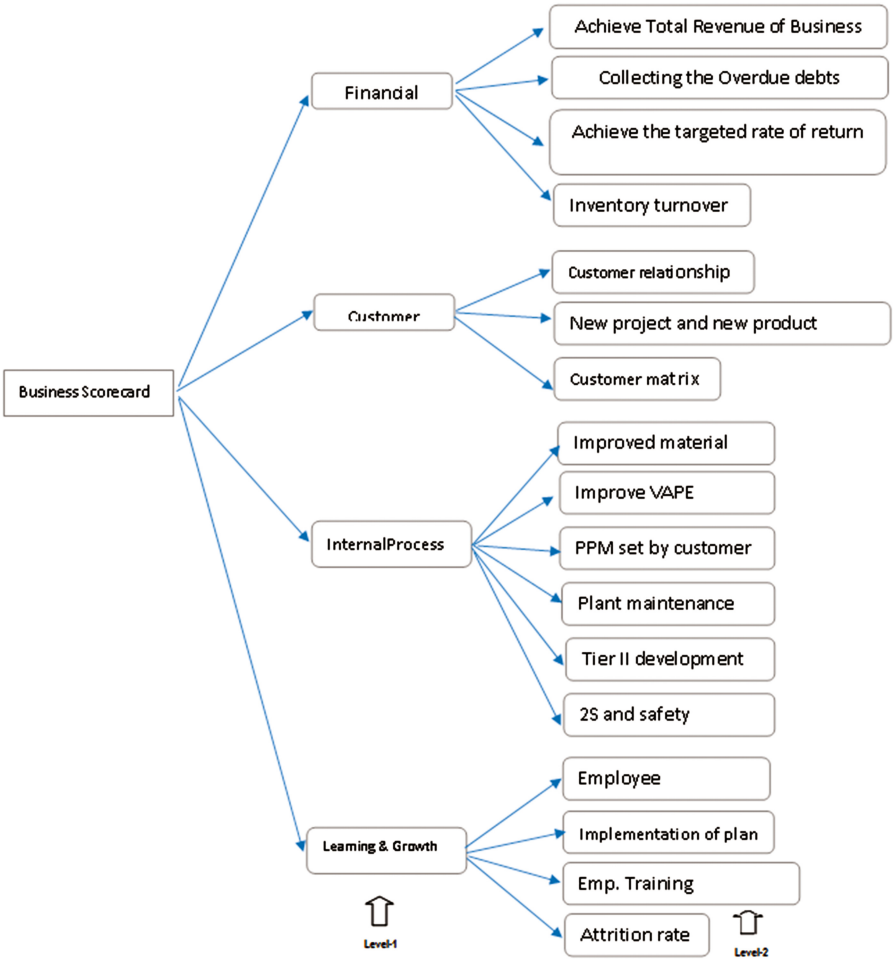

Fig. 1. Balance scorecard

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

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

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

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

Then the Eq. 11 calculates, 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 the Table 6 and using the Eq. 4, we will get the preference(P) of all the attributes. It is given in the Table 7. We can see that the first preference is finance, second is customer, third is internal process and last one is Learning growth. Similarly we calculated the other levels.

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. Preference

Attribute	$\rho(\alpha)$	P
Finance(BS1)	0.88958	1
Customer(BS2))	0.85299	2
Internal process(BS3)	0.852624	3
Learning and growth(BS4)	0.840044	4

5 Comparison Study

Comparing the work IFAHP with Delphi system with IFAHP, We can see that our work has so many advantages over IFAHP method.

1. In the work of IFAHP proposed by Zeshui Xu [4], he used two algorithms. In Algorithm-I, the deviation is calculated using Eq. 11. Suppose the deviation is too high then the author uses Algorithm-II. If still there is no consistency, he starts all over again.
   In the present work we use algorithm-I of Xu [4] and calculate the deviation. The deviation is mostly less than the threshold value $\rho(\alpha)$ since we have done enough iterations in the fuzzy Delphi method.
2. In Zeshuri Xu [4], the work has not given clear picture of how to go about it when Algorithm-II fails. In our present work, we highlighted the following (in step-4): if the preference relation is inconsistent then, go to step-1 (Fuzzy Delphi Method).
3. In Zeshuri Xu [4] work, ranking the supplier in the last level (that is in the alternative criteria only). But in our work, we calculated the preference of each level so that it useful at each and every level of the work.

6 Empirical Result

Based on the suggestion given by the experts the Business Scorecard hierarchy is formed in the Level-1. In that four attributes(factors), the first preference is finance, second is customer, third one is internal process and the last preference is Learning and Growth Table 7. Similarly in the level-2, Finance have four sub attributes after calculating using IFAHP with fuzzy Delphi method, the first preference is achieve total revenue of business, second is achieve the targeted rate of return, third preference is inventory turnover and the last preference is collecting the overdue debts. In Level-2, Customer have three attributes and its ranked based on the above method New product and project, customer relationship and Customer matrix respectively. In the Level-2 one the main attributes is internal process have six sub attributes in the first preference is improve VAPE, second is PPM set by customer, third preference is improved material, fourth one is plant maintenance, fifth is Tire II development and last preference is 2s safety.

7 Conclusion

Recently many of researches are interested to apply the Intuitionistic Fuzzy set in their problems. This work combines Intiutionistic Fuzzy Analytical Hierarchy Process and Fuzzy Delphi Method over 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 are framed based on the suggestion and get the opinion from the experts in automobile sector. This survey was taken using the web site Surveymonkey.com (here the questions are framed and sent link to the experts). In this work we are categories the Business Scorecard. In Each and every level, we rank (preference) the factors of Business Scorecard. The major disadvantage of our work is identify the experts and getting opinion from the experts will take lot of time. Which is useful for the automobile sector and it may improve the our industrial standard and Indian economy.

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