

## Integrating balanced scorecard with fuzzy AHP and ELECTRE III for prioritize agility dimensions in auto parts manufacturing company

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**Abstract:** Today's organizations operate in an environment that rapid changes, they are required to have an adaptive strategies. BSC is such tools strategic planning and implementation in organizations that many applications have in this field. On the other hand, competitive world organization is so that organizations should look to change as one of the main competition and respond to the rapid changes may not be part of the organizational agility. In the past, the solution of decision problems and selection of top option in organizational issues the main goal was only based on maximizing the benefit ratio to cost. But today, with the use of multi-criteria decision, can be several criteria in the form of qualitative and quantitative criteria used to selecting the best option. In this paper, ELECTRE III method is used that is one of the strongest and most effective methods of multi-criteria decision. As a case study, this method for ranking the 4 dimension agility is used in the auto parts manufacturing company in Tabriz. These 4 option evaluated based on 4 criterion BSC. First, criteria weights are calculated using FAHP then entered model. The results showed that Leverage the effect of Individuals and information option is located in the first rank. Finally, offered recommendations based on results for that company.

**Key words:** Agility; MADM; BSC; Fuzzy AHP; ELECTRE III

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### 1. Introduction

With increasing changes in the business environment and become more competitive, Organizations require the production system that It helps to be able to respond to all customer needs. Customers always want more and more diverse products with application and they tend to get more speed (Carlson and Yao, 2000). Today's organizations operate in an environment that rapid changes, they will be required to have an adaptive strategies. In fact, the problem of how organizations can succeed in a dynamic environment and unpredictable, a subject that is known to be a major challenge in today's world. Although various approaches such as Just in Time production, reengineering, virtual organizations and networking have been introduced, But they are the most popular agile organization. In such an environment, agility has become an important feature that, more Influence on organizational performance (Ravichandran, 2007). Agile manufacturing can survive and prosper in a competitive environment defined that the main advantage of the change and uncertainty that as quickly and effectively will react to changing markets according to customer requirements (Sterling, 2008).

On the other hand, the use of a strategic approach to managing organizations is considered in the

planning and what in the assessment In recent years one of the strategic management tools that have been used as a significant, is Balanced Scorecard (BSC). However BSC was initially introduced as a technique to evaluate the operations of the organization, but gradually was used for many companies as a strategic management system. Thus companies went on beyond the goal Kaplan and Norton (1992). Many companies such as Ricoh and Takara Shouze found the BSC can also be analyzed by the exact details of the objectives, evaluation and actual results of operations, causes failure of the system to identify the bad, Therefore, the BSC, was used as a strategic management system. Journal of Harvard Business Review has chosen BSC as one of 75 the most effective ideas that are left in the twentieth century. On the other hand, the decision of the main tasks of the manager. This issue is so important that some of the decisions regarding their management. As regards in real space, there is no decision according to a criterion, using a multi-criteria decision approach, especially in matters of great importance to the organization. Identify the best option for the trustees to decision are difficult without a systematic framework of multi-criteria problems (Wang et al., 2009). As for the need to develop organizational agility to compete in today's turbulent environment and resource limitations, we have a strategic approach to identifying priorities in all aspects of organizational agility and According to strategic thinking to go an aspect of agility and which

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is more important. So in this research it's looking for based on the balanced scorecard (BSC) to prioritize aspects of organizational agility with a multi-criteria approach to study on the auto parts manufacturing company in Tabriz.

## 2. Material and methods

The research based on prioritizes agility dimensions in auto parts manufacturing company which locates in Tabriz Iran. This company produces auto parts. This paper explores the use of BSC with fuzzy AHP and ELECTRE III to prioritize organizational agility dimensions. Based on the interaction financial, customers, internal process and learning and growth perspective, the performance indicates system is developed for prioritizing organizational agility dimensions. After that, a fuzzy AHP and ELECTRE III method is ranked agility dimensions in this company. It aims to convert the subjective cognition of managers into an information entity and confirmation of improvement.

## 3. Theory

### 3.1. Balanced Scorecard (BSC)

David Norton and Norton introduced the Balanced Scorecard in a 1992 Harvard Business

Review article. It added strategic non-financial performance measures to traditional financial metrics to give managers and executives a more 'balanced' view of organizational performance. It is used extensively in business and industry, government, and nonprofit organizations worldwide to align business activities to the vision and strategy of the organization, improve internal and external communications, and monitor organization performance against strategic goals (Kaplan and Norton, 1992).

The success of BSC or a similar device will depend on the clear identification of non-financial and financial variables and their accurate and objective measurement and linking the performance to rewards and penalties. The aim of BSC is to direct, help manage and change in support of the long term strategy in order to manage performance. In general, a BSC system is considered to be a performance measurement system, a strategy evaluation system, and a communication tool, at the same time, defined by the following four distinct perspectives (Kaplan and Norton, 1996).

Kaplan and Norton (1996b) argued that the BSC program is a cause-and-effect relationship among different measurements in the selected perspective, as Fig. 1 shows.

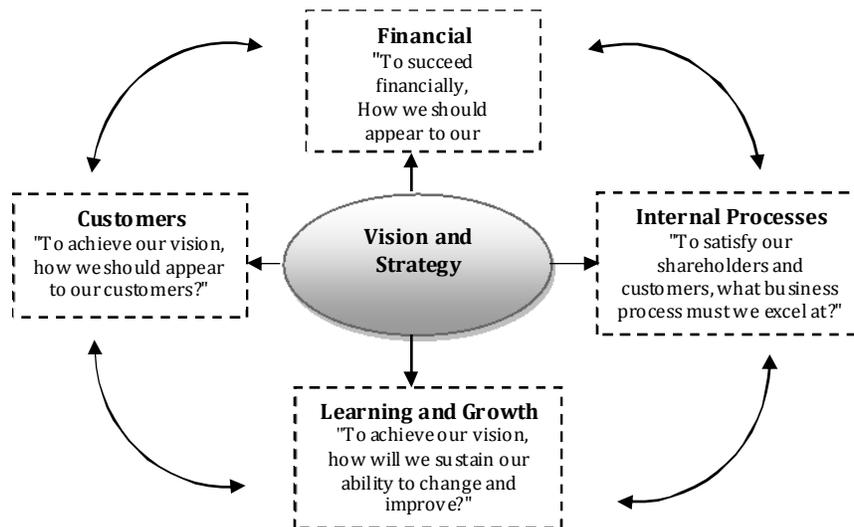


Fig. 1: The four perspectives of the balanced (Kaplan and Norton, 1996)

As mentioned before, the BSC is divided into four perspectives; customer perspective, internal process perspective, learning and growth perspective and financial perspective. In order to give the full meaning of the BSC as a measurement system the four perspectives are analyzed and discussed below:

The customer perspective focuses on the customers' opinion for the company, and how the company wants to be viewed by its customers (Norreklit, 2000). The satisfaction of the customers is a priority to many businesses, especially nowadays where the business environment is even more competitive (Kaplan and Norton, 1992), and

can also act as a very important key performance indicator on the efforts of the business to be successful (Anderson and Sullivan, 1994). The customers usually have four main concerns regarding the product or service that is offered by a business: time, quality, performance and service and cost. Therefore, the company has to align its targets according to these four elements, and subsequently transform these targets into specific measures (Kaplan and Norton, 1992).

The internal processes perspective refers to internal business processes. Metrics based on this perspective allow the managers to know how well

their business is running and whether its products and services conform to customer requirements. These metrics have to be carefully designed by those who know these processes most intimately; with unique missions these are not something that can be developed by outside consultants.

The learning and growth perspective includes employee training and corporate cultural attitudes related to both individual and corporate self-improvement. In the current climate of rapid technological change, it is becoming necessary for knowledge workers to be in a continuous learning mode. Metrics can be put into place to guide managers in focusing training funds where they can help the most. In any case, learning and growth constitute the essential foundation for success of any knowledge worker organization.

The financial perspective is the last perspective of the model of BSC. This perspective refers to the financial view of a company as presented to its shareholders and whether the strategy, implementation and execution of the company are contributing to bottom-line improvement (Kaplan and Norton, 1992a). The financial performance measures provide information based on company results of past events. The measures as well as the objectives of the other three perspectives of the BSC focus on the financial targets and objectives, which generally have to do with growth, profitability and shareholder value (Kaplan and Norton, 1996b). However

Kaplan and Norton (1992) state that because the financial indicators do not influence customer's and employee's satisfaction the businesses should not use them as metrics to direct them to their strategic vision. As a result, the businesses should not use only financial data but also strategy models and measurements that emphasize to the total of the business's strategy. Indicatively some of the financial measures that can be used are: gross margin percentage, cost reductions in key areas, return on investment and return on capital employed (Collis, Holt and Hussey, 2012; Kaplan and Norton, 1996b). BSC helps everyone in an organization understand and work towards a shared vision. A completed scorecard system aligns the organization's picture of the future, with business strategy, desired employee behavior and day-to-day operations. It is therefore a very important strategic management tool which helps an organization not only to measure performance, but also decide (manage) the strategies needed to be adopted (modified) so that the long term goals are achieved (Sharma, 2009). BSC gives us a valuable tool for enabling employees to understand the company's situation, a must if the company is to achieve the dynamism it needs to be competitive in the long run. It also provides us with useful documentation for continually developing those measures for control which most quickly will guide the company towards achieving its goals and its vision.

### 3.2. Theoretical foundations of agility

Agility improves the organization's capability to offer high quality products and services. Therefore, it could play essential role for increasing effectiveness. Agile enterprises are always prepared to learn more, which increases profitability arising from utilizing new opportunities. There are strong motivations to show agile production is the necessary condition for competitiveness. Various organizations were pressured heavily to access more flexibility, shorter delivery time and more diversity of products and services since the beginning of the 1990's. Therefore, many firms have moved to dominate challenges such as variable demand of consumers, demand for high quality and minimum cost of production as well as responding special customers' requirements. They reengineered their businesses, renewed the structure in responding reacting to such challenges, and developed a modern method called organizational agility. In 1991 a group included 150 executive top managers of industry took part in a survey in which manner of competition in the American manufacturing organizations during the next 15 years was investigated. Thus "Agile Manufacturing Enterprise Forum (AMEF)" dependent on Iacocca institute was built in Lee Hay University and the term agile production was introduced (Richards, 1996). There is no widely accepted definition for agility since this is a new topic. Several researchers have been active in this regard since 1991 onwards and each one represented different definitions. Some of these definitions are classified in the following,

- Agility refers capability of successful production and selling of an extensive range of products with low cost, high quality, short delay times and a variety of classes' size which create value for various and certain customers through production based on mass customer needs (Van Assen et al., 2001).
- It is the ability to respond effectively to events that are changed rapidly and are unexpected (Dove, 1996).
- According to Yusuf et al. (1999), agile is searching competitive principles successfully in terms of speed, flexibility, creativity, being proactive, quality and profitability through integration of resources which could be re-shaped. In addition, it is the best practical technique in a specialized environment to provide services and products based on customers' requirements in a market environment where quick changes are occurred.
- Agility is, in fact, a new paradigm to engineer competitive firms. The proposed paradigm indicates a step forward, which generates new meanings for better and successful performance and practically is a strategic approach to look for new conditions of business environment. Responding to different changes and looking into their advantages through strategic utilization of manufacturing, service and managerial tools and techniques are the main concepts of agility (Sharifi and Zhang, 1999).

Goldman et al. (1995) identified four strategic dimensions of Agile manufacturing which are applicable, also, to non-manufacturing enterprises. They are as follows:

- (1) Enriching the customer,
- (2) Cooperating to enhance competitiveness,
- (3) Organizing to master change and uncertainty, and
- (4) Leveraging the impact of people and information.

The Agile Manufacturing Research Institute uses these strategic dimensions in considering the tactical and technological dimensions of agility (DeVor et al., 1997).

These dimensions will provide a useful context for examining how Internet technology (intranets and the Internet) contributes to agility.

Enriching the customer involves supporting the customer's processes in a way that is perceived by the customer to be enriching. Rusty Patterson, Industry President and CEO of the Agility Forum of Bethlehem, PA describe this as "giving the customer what he wants throughout changing needs and throughout the life of the product" So that "he won't have to go anywhere else" (Litsikas, 1997). By enriching its customers an enterprise can become a permanent part of its customers' processes.

Cooperation is a cornerstone of agility. It is an important philosophical underpinning for agility (Nagel and Dove, 1993). Cooperation is necessary within an organization as a means of synchronizing the many people and organizational subunits that play a role in bringing about the actions required to continually meet ever-changing.

Customer needs. The need for cooperation extends beyond the firm to customers, suppliers, stockholders, government, and even competitors. Team membership can be extended to any organization, or entity that can help an enterprise become and remain a valuable enabler in the customer's process.

Flexibility is the key! As noted, an agile enterprise must be appropriately organized to thrive on change and uncertainty (DeVor et al., 1997). As any part of the firm's environment changes, it must be sufficiently flexible to reorganize its human systems and technical systems to not just adapt to change, but to take advantage of change.

It takes more than advanced technology to achieve agility. Agility requires an entrepreneurial company culture that "leverages the impact of people and information on operations" (DeVor et al., 1997). The entrepreneurial culture required for agility should encourage creativity, the free flow of information and exchange of ideas, cooperation, collaborative intra and inter-organizational work, individual initiative and personal responsibility. It is a culture in which people and groups must be empowered to act in response to present and future customer needs.

### 3.3. The ELECTRE $\square$

Managers and decision-makers usually some organizational issues faced with a number of options and number of indicators or benchmarks for assessment and most essential challenges they choose the most appropriate option or options are prioritized according to the criteria defined. In this regard Multi Attribute Decision Making (MADM) techniques can be a way to resolve these issues. In fact, using this technique, and according to various criteria to decide and executive the best option or options to choose from among the options decision. Decision making methods are very diverse and generally are divided into two categories compensatory and non-compensatory methods. Compensation methods include methods that enables the exchange value of the index exists, In other words, changes in the value of a measure can be adjusted by changing the value of other criteria, it will be accepted if you decrease the value of a measure cause to increase the value of other criteria. Non-compensatory methods include ways, in which the criteria are not allowed to exchange value that is the disadvantage of a measure is not compensated by the advantage of the other criteria. As a result of this method are considered and compared each index alone are based on the index are done. In some of these methods may didn't need to accusation information the decision maker (Asgharpour, 2008.). These models are leading to a concrete answer. Among the non-compensatory methods, efficient method (ELECTRE) was provided in 1968 by Roy, by taking various measures And set a high priority areas, weak and incuriosity to compare different options making deals by a person or group decision-making. Basic of ELECTRE method is no rating where check out validity or invalidity for each pair of options, In addition, what distinguishes other methods the method of multi-criteria decision making it is non-compensatory basis.

On the other hand, ELECTRE III method is developed ELECTRE I accordingly, and in this way, rather than ranking the options used of the new concept known as non-ordinal concept The power of this approach in terms of the existing doubts at criteria and proposes a solution to deal with them on validity of this method is added, In short, this method has been used in various practical and have been excellent results (Bagerzadeh et al., 2002). This algorithm is as follows:

The first step is the formation of matrix analysis; which requires the determination of threshold values superiority, indifference and is vetoed. These factors include the Preference Threshold, Indifference Threshold and rejection or Veto Threshold. By choosing appropriate values for the thresholds proposed you can decide the issue of state compensation method, the fuzzy transferred.

The second step is to calculate Concordance indexes  $c(a, b)$  and Discordance index  $d(a, b)$  and is formation of concordance matrix and discordance matrix. Suppose  $k_j$  is the coefficient or weight for

each criterion  $j$ , Concordance index of the form of Eq (1) is defined as:

$$C(a, b) = \frac{1}{K} \sum_{j=1}^r k_j c_j(a, b)$$

$$K = \sum_{j=1}^n k_j$$

Equation (1)

$$C_j(a, b) = \begin{cases} \text{If } g_j(a) + q_i \geq g_j(b) & 1 \\ \text{If } g_j(a) + p_j \leq g_j(b) & 0 \\ \text{others} & \frac{p_j + g_i(a) - g_i(b)}{p_j + q_i} \end{cases}$$

$(a, b)$  coupling an option that can be compared.  $C_j(a, b)$  is concordance index for criterion  $j$ ,  $q_i$  and  $p_j$  are indifference and preference thresholds are values respectively.  $g_j(a)$  is amount the value of option  $a$  on the criterion  $j$ .  $C(a, b)$  shows the degree of coordination.  $K_j$  important factor for the criterion  $j$ . Also the inconsistency is defined as in Eq (2), that  $(a, b)$  coupling an option that can be compared.  $q_i$  and  $p_j$  are indifference and preference thresholds are values respectively.  $g_j(b)$  is amount the value of option  $b$  on the criterion  $j$ .  $d_j(a, b)$  is coordination index for criterion  $j$  and  $V_j$  is the veto threshold value.

$$d_j(a, b) = \begin{cases} \text{If } g_j(a) + p_j \geq g_j(b) & 0 \\ \text{If } g_j(a) + v_j \leq g_j(b) & 1 \\ \text{others} & \frac{g_j(b) - g_i(a) - p_j}{v_j - p_j} \end{cases}$$

Equation (2)

The third step is to evaluate the Credibility index of the Eq (3) are as follows:

$$S(a, b) = \begin{cases} \text{If } c(a, b) \geq \forall_j d_j(a, b) \leq c(a, b) & \\ c(a, b) * \Pi_j e_j(a, b) \frac{1 - d_j(a, b)}{1 - c(a, b)} & \end{cases} =$$

Equation (3)

$S(a, b)$  shows superior a option than  $b$  or in other words, this means that at least a good option is option  $b$ .  $d_j(a, b)$  is discordance index for criterion  $j$  and  $C(a, b)$  shows the degree of coordination.

The fourth step is to determine the rank and prioritize the options. General procedure for the

operation of this structure is making the rise and fall of the ranking is Z1 and Z2 that will be achieved from sharing the final ranking method. For this purpose, the parameter  $\lambda$  is defined in the form of Eq (4).

$$\lambda = \max S(a, b)$$

$a, b \in A$

Equation (4)

This parameter determines the amount of credit that only the values of  $S(a, b)$  which are considered to be close to it. In this process, a new parameter called  $S(\lambda)$  is obtained of Eq (5), Where  $\alpha$  and  $\beta$  change in the sensitivity analysis and default values are  $\alpha = -0.15$  and  $\beta = 0.3$ . Finally value of  $\lambda - S(\lambda)$  is calculated. T matrix is defined in Eq (6).

$$S(\lambda) = \alpha\lambda + \beta$$

Equation (5)

$$T(a, b) = \begin{cases} \text{If } S(a, b) > \lambda - s(\lambda) & 1 \\ \text{others} & 0 \end{cases}$$

Equation (6)

Then utility is shown for each item  $Q(a)$  and a number of options that a project will have ratings, minus the number of projects that have a rating. Simply  $Q(a)$  is the sum of the numbers in the row minus the sum of the numbers in the columns of the matrix T is defined for each option.

### 3.3.1. Preparing efficiency matrix

To implement the model in ELECTRE-III preparing efficiency matrix is one of the most important steps of the inputs of the model. In the efficiency matrix as a matrix to compare criteria against options. This order forms is provided in the administrative and academic expert instructors were placed. The basis of these forms was that experts how quality criteria describe by assume that implementation all the options as good, very good, moderate, bad or very bad. Then these descriptive amounts has become to numerical amount of 1 to 5 as is shown in Table 1. Accordingly, criteria amount is placed as raw in efficiency matrix then enters the E-III software.

Table 1: Rating method of options to satisfy the criteria

Item	numerical value	General effect
approximately don't satisfy the relevant criteria	1	Very bad
Satisfy the criterion of minimal	2	Bad
Satisfies the relevant criteria moderate	3	Moderate
Satisfies to be the criteria But is lower the greatest satisfaction	4	Good
Almost completely satisfy the relevant criteria	5	Very good

### 3.3.2. Determine the amounts of threshold value and weight of criteria

Another input data of ELECTRE-III model that need to be carefully is the values amount of the threshold of indifference, preference and veto. Importance and weight of each criterion in prioritize agility dimensions the third group is the data that is needed to implement the model. In this section as for to the research problem, at first should be drawn

decision tree. In Balanced decision tree must criteria weight (4 dimensions of the BSC) obtained through paired comparisons and comparisons options are evaluated therefore agility dimensions are based on the following dimension and points are calculated. Fig. 2 shows the decision tree is based on four criteria BSC and four options of agility dimensions.

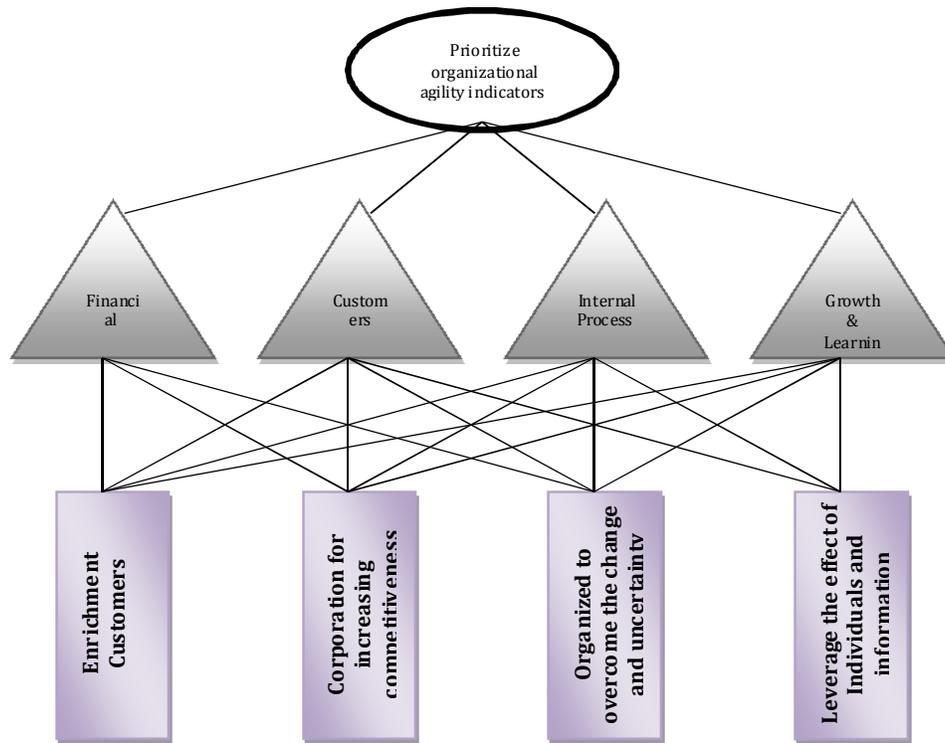


Fig. 2: the decision tree is based on four criteria BSC and four options of agility dimensions

In Extant Analysis (EA) method are used triangular fuzzy numbers for paired comparisons. Using a range of  $1/9$  to 9 Saati can be paired comparison matrix to form a triangular numbers. In this step, decision maker your preferences express the paired comparison of each level to higher levels of a fuzzy way. In order accuracy in results the

questionnaire was designed to Send for 6 mangers of company that is based on calculation. According to experts opinion and was calculated using Fuzzy AHP method that finally shown on table (2) outcomes of Important ratio in the criteria and options.

Table 2: Importance ratio of criteria and options using of FAHP

Criteria \ Options	Financial	Customers	Internal Process	Growth and Learning
Enrichment Customers	0.234	0.321	0.201	0.302
Corporation for increasing competitiveness	0.265	0.267	0.212	0.243
Organized to overcome the change and uncertainty	0.243	0.192	0.243	0.134
Leverage the effect of Individuals and information	0.258	0.220	0.164	0.321

#### 4. Results

In the previous sections of this paper was to study the criteria and various options were considered. In total, four options are evaluated against four criteria. At first should be formed efficiency matrix; therefore, all options are checked against the every criterion and the value is obtained. As mentioned in the previous section about the criteria is used descriptive methods and by comparison a description of the options for each criterion, is obtained assessment of each option to the desired criteria. Finally, the results of the evaluation of the effectiveness matrix of decision are shown on Table 3.

As previously noted, amounts for each of the cells of the table has been achieved by evaluating each option relative to the criterion. After the efficiency matrix to give up Table 4. The second column of the table is the criteria weight that is obtained by Fuzzy AHP method in the previous step. The third to fifth column of the table shows the amounts used key three-point range. As mentioned these range suggested by some experts. The third column shows the range of rejection or veto. Numbers written in this column is for the relevant criteria, if we compare the two options together to meet this criterion. This number specifies range of rejected an option and the reason is known for the veto threshold value. The fourth column shows the superiority.

**Table 3:** Effectiveness matrix of decision prioritization of agility dimensions

Options \ Criteria	Financial	Customers	Internal Process	Growth and Learning
Enrichment Customers	2	4	3.2	2.7
Corporation for increasing competitiveness	4.4	2.5	2.8	3.1
Organized to overcome the change and uncertainty	2	3.5	4.2	4.2
Leverage the effect of Individuals and information	3.8	3	4.1	4.3

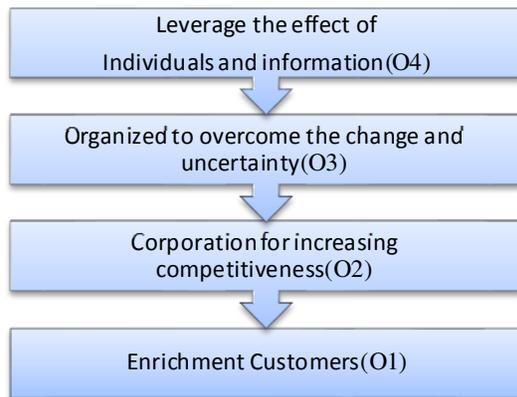
Hence, if be compared Numbers of criterion at efficiency matrix, the superiority of either of the options that are desired criteria. So if the value of the option in the size range of criteria is superior, it would be a better option and this area is known to be superior threshold value. The fifth column is the indifference range. Hence, if little difference has the value of two options at a specified criterion, both

options are selected but if the value of options to reach to indifference range one of them is selected. So the indifference range indicates lack of superiority of one option over the other options, i.e. in the range of options to meet the criterion turns out to have no superior, So this is the indifference threshold value is known.

**Table 4:** Amounts of threshold values and weighting of criteria

Criteria	Criterion weight(W)	Veto threshold value(V)	Priority threshold value(P)	Indifference threshold value(I)
Financial	0.261	3	2	1
Customers	0.185	2	1	0.2
Internal Process	0.369	2	1	0.2
Growth and Learning	0.185	3	2	1

By entering efficiency matrix in Table 4 and information of the weighting of criteria and priority ranges, indifference and veto, runs E-III method that the results are ranked in order of options is shown in Fig. 3.



**Fig. 3:** Ranking options as graphical based on output from the E- III software

On the other hand, output Software E-III is Table 5, that this table shows the comparison matrix of options relative to each other.

**Table 5:** Comparison matrix of options relative to each other based on output from the E- III software

Options	(O1)	(O2)	(O3)	(O4)
(O1)	I	P-	P-	P-
(O2)	p	I	P-	P-
(O3)	P	P	I	P-
(O4)	P	P	P	I

### 5. Conclusions and recommendations

In this study, using a multi-criteria decision method were investigated to assess priorities of organizational agility dimensions the perspective of strategic and based on BSC. In this study criteria weights was extracted using FAHP method and for the ranking was used ELECTRE-III method. The results of this study are summarized below:

- Option of Leverage the effect of Individuals and information has been ranked first. This means that the company will try to use of the impact of information on employee and on the other hand, are encouraging innovation. So that the management puts at their disposal information resources needed of people in organization accurately and in a timely.
- As regards enrichment customers option is located last rank. Inevitably the company should give importance to the status of customers over the past and pricing based on are not the cost of finished goods but have apply based on the value for the customer's needs.

Option of organized to overcome the change and uncertainty rather than option of corporation for increasing competitiveness is a higher priority and it indicates that the company will try to overcome environmental changes by organizing people and organizational resources and do not pay much attention to cooperate with competitors in order to access to the market.

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