A CONCEPTUAL FRAME WORK SUPPLIER SELECTION IN FOOD PROCESSING PLANT USING MCDM TECHNIQUE

Manoj kumar soni[1], **Sanjay Kumar singh**[2]
[1]MTech scholar, Department of Mechanical Engineering, CSIT Durg, C.G., India
[2]Professor, Department of Mechanical Engineering, CSIT Durg, C.G., India
Email - manojsoni5031@gmail.com

Abstract: The objective of this paper is to demonstrate the application of the Analytic Hierarchy Process (AHP), a popular multi criteria decision support tool, in assessment and selection of (best) suppliers for food industry, namely food wholesalers. Cooperation with suppliers is an important element of quality management. One of the major problems that modern companies have is selection of the best supplier of raw materials, equipment, services, etc. Food sector was selected as particularly sensitive towards potential risks of selection of a wrong supplier. The examples of factors that influence the choice of suppliers include i.e.: price, possibility of discounts, innovativeness. These factors have been organized into hierarchical structure and evaluated by the relevant experts – representatives of food wholesalers in India. They indicated, using the 9-point fundamental scale, the relative importance of each factor. Such model can be used as a universal and systematic tool to evaluate suppliers in any company.

Key Words: *AHP, supplier selection, supplier evaluation, food wholesaler, MCDM*

1. INTRODUCTION:

Today in India, many of the corporations are facing problem due to rapidly changes in technological innovations and ever-changing client necessities. Also some of the corporations understand that it is tough to get product at the proper price and within the right quality for survival in the market. Therefore, eminent supplier is needed for proper development & success of supply chain management. Multiple Criteria Decision Method (MCDM)in supplier selection process involves several numbers of criteria that may be tangible and intangible. The analysis of criteria for choosing and analyzing the performance of supplier has been a major factor of focus for many researchers and buying practitioners to give a transparent method of selecting the supplier. Supplier selection process requires a scientific and rational model. During this analysis, a really comprehensive application of Analytic Hierarchy method (AHP) is used along sensitivity analysis to decide the best supplier. The AHP method is intended to solve complicated multi-criteria decision issues. It offers decisions by organizing the perception, feelings and judgments into a framework that solves the matter and helps in deciding the desired goal. The dimensions used for comparisons in AHP provides the decision-maker to include the specialists expertise and information that indicate what number of times an element dominates another element. In this study a attempt is made to finalize the best cement provider with the help of AHP model within the situation of Indian food processing industries.

2. BACKGROUND:

The managing team of food processing industries requires essential tools & capital assets that helps them to perform their site work and task assigned to them effectively. The higher authority of companies do not provide any clear guidelines to select the supplier based on required criteria which leads to wrong perception in supplier selection process. This means that, there is no appropriate method to finalize the right suppliers. The higher authorities of an organization are selecting the vendors without following a systematic approach for selection process. The research is an attempt which deals with supplier selection in order to improve the supplier selection process in food processing Company. In food processing Company many constraints and restrictions are there during the supplier selection process. Due to this, whole criteria and sub-criteria’s are taken under consideration to control and finalize the supplier selection process. In this work a model is developed for selecting the best supplier which is capable to meet certain criteria.

In this research both the subjective and the objective data are considered for supplier selection on the basis of many criteria and sub criteria’s of company. For achieving the required level of proficiency in selection process, it is essential to develop the vendor selection model which is based on analytical hierarchy process.

2.1 Data collection Methodology

This section introduces the research methods deployed in this study. It includes two main parts: data gathering methods and data analysis methods .In the end of this section. The structure of this paper is also presented shown in figure 2.1

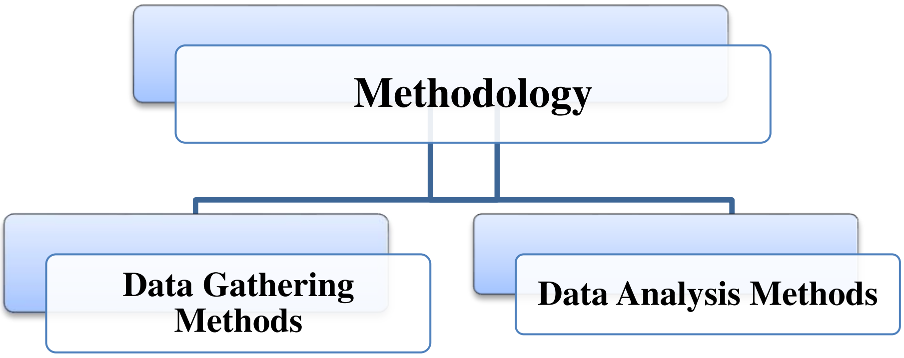

Fig1.1: main parts of methodology

2.1.1 Data gathering methods

The paper firstly used online search engine – alibaba.com – to build a long list of potential supplier's basic requirements. Then pre filters. Which were defined by the author, were used to locate most potential supplier candidates – which in this case was 7 suppliers. The filtering process will be explained in the case studies.

This research utilized a questionnaire survey to gather primary data for analysis. The questionnaire was distributed to the 7 individual suppliers in India through emails to supply companies' contact person. Online questionnaire survey is quick and low cost which suited the case background and the author's objectives. The author prepared the questions on the questionnaire with regard to selected supplier evaluation criteria and sub-criteria which will be discussed in Chapter 4. The original questionnaire was in English.

The questionnaire consisted of four parts:

1) General information – contact information;

2) Business information – company profile and management;

3) Production information – production capabilities and customization capability

4) Product specifications – price. Variety and quality features.

The questionnaire design included fill-in questions. Click boxes and open-ended questions receiving both qualitative and quantitative answers With a 100% response rate. the findings were considered a meaningful material for comparing and selecting the best supplier for the case company. The secondary data were gathered through data mining which involved the search for published data from reliable sources including published literature and electronic re- search papers. Journals and articles. For the case studies. the author also deployed information from reliable websites. such as supplier companies' website and the Inter- net supplier search engine – alibaba.com. Detailed explanations will be presented in the case study chapter.

2.1.2 Data analysis methods

The author used the Analytical Hierarchy Process (AHP) tool for a multivariate analysis of collected data. As supplier selection is a multi-criteria decision making problem which naturally needs a method that can analyze multiple measurements including both qualitative and quantitative information. The AHP method's widespread usage in supplier evaluation and its effectiveness meet the data analysis requirements. The AHP method deploys a pair-wise comparison matrix to interpret and measure qualitative data. In the same process, qualitative data is transferred to quantitative figures through computations. The final results of the AHP tool implementation are presented in quantitative form and could be easily interpreted by the ranking of total scores.

3. MCDM TECHNIQUE:

3.1 Introduction

The Multi criterion Decision-Making (MCDM) are gaining importance as potential tools for analyzing complex real problems due to their inherent ability to judge different alternatives (Choice, strategy, policy, scenario can also be used synonymously) on various criteria for possible selection of the best/suitable alternative (s). These alternatives may be further explored in-depth for their final implementation.

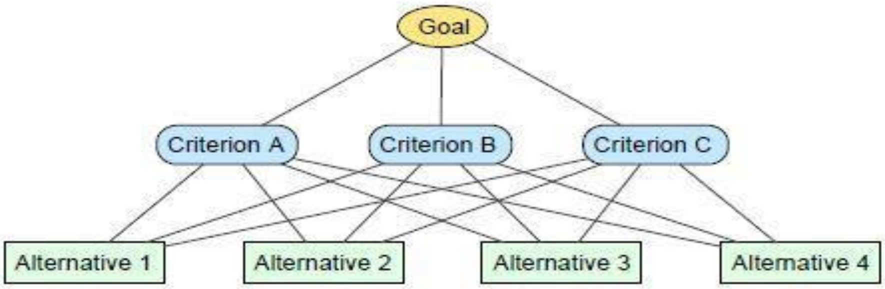

Figure 3.1 Multi criteria decision making (MCDM) Tree

Multi criterion Decision-Making (MCDM) analysis has some unique characteristics such as the presence of multiple non-commensurable and conflicting criteria, different units of measurement among the criteria, and the presence of quite different alternatives. It is an attempt to review the various MCDM methods and need was felt of further advanced methods for empirical validation and testing of the various available approaches for the extension of MCDM into group decision-making situations for the treatment of uncertainty .The weighted sum model (WSM) is the earliest and probably the most widely used
method. The weighted product model (WPM) can be considered as a modification of the
WSM, and has been proposed in order to overcome some of its weakness. The analytic hierarchy process (AHP), as proposed by Saaty is a later development and it has recently become popular. Recently modification to the AHP is considered to be more consistent than the original approach. Some other widely used methods are the ELECTRE and the TOPSIS methods.

3.2 Description of Some MCDM methods

There are three steps in utilizing any decision-making technique involving numerical analysis of alternatives: Determining the relevant criteria and alternatives Attach numerical measures to the relative importance to the criteria and the impact of the Alternatives on these criteria Process the numerical values to determine a ranking of each alternative. Numerous MCDM methods such as ELECTRE-3 and 4, promethee-2, Compromise Programming, Cooperative Game theory, Composite Programming, Analytical Hierarchy Process, Multi-Attribute Utility Theory, Multi criterion Q-Analysis etc are employed for different applications. However, more research is still to be done to explore the applicability and potentially of more MCDM methods to real-world planning and design problems to reduce the gap between theory and practice.

3.2.1 The WSM Method

The weighted sum model (WSM) is probably the most commonly used approach, especially in single dimensional problems. If there are m alternatives and n criteria then, the best alternative is the one that satisfies the following expression,
AWSM =max ΣWSM for i=1,2,3,----m
Where A wsm is the WSM score of the best alternative, n is the number of decision
criteria, ao is the actual value of the i-th alternative in terms of the j-th criterion, and wf is the weight of importance of the j-th criterion. The assumption that governs this model is the additive utility assumption. That is the total value of each alternative is equal to the sum of the products given in the equation 4.1. In single-dimensional cases, where all the units are same, the WSM can be used without difficulty. Difficulty with this method emerges when it is applied to multi-dimensional MCDM problems. Then, in combining different dimensions, and consequently different units, the additive utility assumption is violated and the result is equivalent to 'adding apples and oranges'.

3.2.2 The WPM Method

The weighted product model (WPM) is very similar to the WSM. The main difference is that instead of addition in the model there is multiplication. Each alternative is compared with the others by multiplying a number of ratios, one for each criterion. Each ration is raised to the power equivalent to the relative weight of the corresponding criterion. In general, in order to compare two alternatives AK and AL, the following product has to be calculated
R (AK/ AL) =akj/aij (4.2)
Where n is the number of criteria, a is the actual value of the i-th alternative in terms of the j-th criterion, and wf is the weight of the j-th criterion. If the term R(AK/ AL) is greater than or equal to one, then it indicates that alternative AK is more desirable than alternative AL (in the maximization case). The best alternative is the one that is better than or at least equal to all other alternatives.
The WPM is sometimes called dimensionless analysis because its structure eliminates
any units of measure. Thus, the WPM can be used in single- and multi-dimensional
MCDM. An advantage of the method is that instead of the actual values it can use
relative ones

3.2.3 The AHP method

The Analytic Hierarchy Process (AHP) decomposes a complex MCDM problem into a system of hierarchies. The final step in the AHP deals with the structure of an m*n matrix (Where m is the number of alternatives and n is the number of criteria). The matrix is constructed by using the relative importance of the alternatives in terms of each criterion. Analytic Hierarchy Process (AHP) is an MCMD method based on priority theory. It deals with complex problems which involve the consideration of multiple criteria/alternatives simultaneously. Its ability to incorporate data and judgment of experts into the model in a logical way, to provide a scale for measuring intangibles and method of establishing priorities to deal with interdependence of elements in a system to allow revision of judgments in a short time to monitor the consistency in the decision-maker's judgments to accommodate group judgments if the groups cannot reach a natural consensus, makes this method a valuable contribution to the field of MCDM. The methodology is capable of Breaking down a complex, unstructured situation into its component parts, Arranging these parts into a hierarchic order (criteria, sub-criteria, alternatives etc.) Assigning numerical values from 1 to 9 to subjective judgments on the relative importance of each criterion based on the characteristics Synthesizing the judgments to determine the overall priorities of criteria/sub-criteria/ alternatives Eigenvector approach is used to compute the priorities/weights of the criteria/ sub criteria/alternatives for the given pairwise comparison matrix. In order to fully specify reciprocal and square pairwise comparison matrix, N (N-1)/2 pairs of criteria/sub criteria / alternatives are to evaluated. The Eigen vector corresponding to the maximum eigenvalue (λMAX) is required to be computed to determine the weight vectors of the criteria/sub-criteria/alternatives. Small changes in the elements of the pairwise comparison matrix imply a small change in λMAX and the deviation of λMAX from N is a deviation of consistency. This is represented by Consistency Index (CI). i.e. (λMAX –N)/(N-1). Random Index (RI) is the consistency index for a randomly-filled matrix of size. Consistency ratio (CR) is the ration of CI to average RI for the same size matrix. A

CR value of 0.1 or less is considered as acceptable. Otherwise, an attempt is to be made to improve the consistency ny obtaining additional information. Prof. Thomas L. Saaty (1980) originally developed the Analytic Hierarchy Process (AHP) to enable decision making in situations characterized by multiple attributes and alternatives. AHP is one of the Multi Criteria decision making techniques. AHP has been applied successfully in many areas of decision-making. In short, it is a method to derive ratio scales from paired comparisons.

Four major steps in applying the AHP technique are:

1 Develop a hierarchy of factors impacting the final decision. This is known as the AHP decision model. The last level of the hierarchy is the three candidates as an alternative.

2 Elicit pair wise comparisons between the factors using inputs from
Users/managers

3 Evaluate relative importance weights at each level of the hierarchy

4 Combine relative importance weights to obtain an overall ranking of the three
Candidates. While comparing two criteria we follow the simple rule as recommended by Saaty (1980). Thus while comparing two attributes X and Y we assign the values in the following manner based on the relative preference of the decision maker in this case the HR Managers Intensity of Importance Definition

Table 3.1 preference level

Preference Level	Numerical Value
Equally preferred	1
Equally to moderately preferred	2
Moderately preferred	3
Moderately to strongly preferred	4
Strongly preferred	5
Strongly to very strongly preferred	6
Very strongly preferred	7
Very strongly to extremely preferred	8
Extremely preferred	9

Reciprocals of the above If activity i has one of the above numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i. 1.1 – 1.9 When elements are close and nearly indistinguishable

5. PROCEDURE OF AHP

According to Russell and Taylor (2008) AHP is a quantitative method for ranking decision alternatives and selecting the one among given multiple criterion. AHP is a process of developing numerical score to rank each decision.

The step by step procedure to carryout AHP is given below:

When making policy decisions in planning, it is extremely important to evaluate the possible alternatives carefully. The Analytical Hierarchy Process (AHP) allows the policy analyst to do this by structuring the problem hierarchically and guiding him through a sequence of pair wise comparison judgments.

Step 1: Setting up hierarchy

The hierarchy structure is shown in the Figure 4.1 where level 0 is the goal of MCDM model, level 1 is the factors considered for the analysis and level 2 is the alternative suppliers available. Here, AHP is applied to select suitable supplier for the case industry by considering the factors like

1) Quality
2) Quantity

3) Delivery Time
4) Demand
5) Cost.

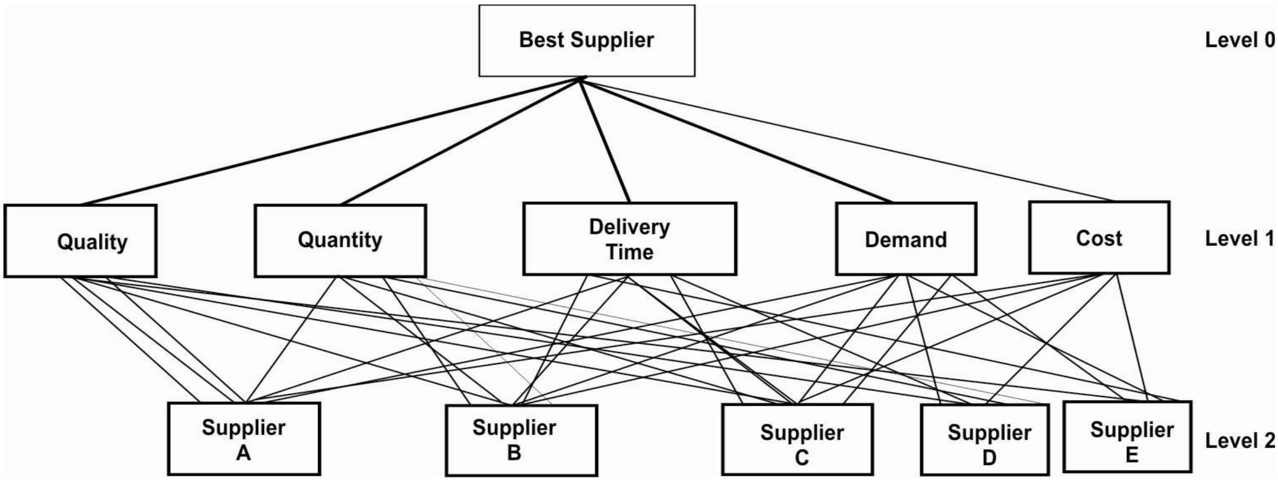

Figure 4.2 Hierarchical tree of the AHP for the Supplier Selection Process

Step 2: Comparison of characteristics

In this procedure AHP is applied for Supplier for food processing machine by considering all the five suppliers is shown as example.

Table 4.1 initial body matrix

	SA	SB	SC	SD	SE
Supplier A	1	2	3	3	2
Supplier B		1	3	2	3
Supplier C			1	2	3
Supplier D				1	2
Supplier E					1

The initial value is assigned to the upper triangle matrix by collecting the data from senior people of the case industry. Saaty Scale 1-9 is assigned to the upper triangle matrix in the order of their importance.

Table 4.2 Standard Preference

Preference Level	**Numerical Value**
Equally preferred	1
Equally to moderately preferred	2
Moderately preferred	3
Moderately to strongly preferred	4
Strongly preferred	5
Strongly to very strongly preferred	6
Very strongly preferred	7
Very strongly to extremely preferred	8
Extremely preferred	9

To fill the lower triangular matrix, we use the reciprocal values of the upper diagonal. If aij is the element of row i column j of the matrix, then
the lower diagonal is filled using this formula

$$a_{ji} = \frac{1}{a_{ij}} \quad \ldots(4.1)$$

Thus comparison matrix is completed as follows:

Table 4.3 comparison matrix

	SA	SB	SC	SD	SE
Supplier A	1	2	3	3	2
Supplier B	0.5	1	3	2	3
Supplier C	0.33	0.33	1	2	3
Supplier D	0.33	0.5	0.5	1	2
Supplier E	0.5	0.33	0.33	0.5	1

Note: All the element in the comparison matrix are positive, or aij > 0.

Step 3: Establish priority vector

Here, there is 5 x 5 reciprocal matrix from paired comparison.

Table 4.4 comparison matrix

	SA	SB	SC	SD	SE
Supplier A	1	2	3	3	2
Supplier B	0.5	1	3	2	3
Supplier C	0.33	0.33	1	2	3
Supplier D	0.33	0.5	0.5	1	2
Supplier E	0.5	0.33	0.33	0.5	1

Sum each column of the reciprocal matrix

Table 4.5 reciprocal matrix

	SA	SB	SC	SD	SE
Supplier A	1	2	3	3	2
Supplier B	0.5	1	3	2	3
Supplier C	0.33	0.33	1	2	3
Supplier D	0.33	0.5	0.5	1	2
Supplier E	0.5	0.33	0.33	0.5	1
Sum	2.67	4.17	7.83	8.5	11

Then divide each element of the matrix with the sum of its column and find normalized relative weight. The sum of each column is 1.

Table 4.6 relative weight matrix

Supplier A	1/2.67	1/4.17	1/7.83	3/8.5	2/11
Supplier B	0.5/2.67	1/4.17	3/7.83	2/8.5	3/11
Supplier C	0.33/2.67	0.33/4.17	3/7.83	2/8.5	3/11
Supplier D	0.33/2.67	0.5/4.17	0.5/7.83	1/8.5	2/11
Supplier E	0.5/2.67	0.33/4.17	0.33/7.83	0.5/8.5	3/11
Sum	1	1	1	1	1

The normalized principal Eigen vector can be obtained by
Averaging across the rows;

$$w = 1/5 \begin{vmatrix} 0.375 + 0.48 + 0.383 + 0.353 + 0.182 \\ 0.188 + 0.24 + 0.383 + 0.235 + 0.273 \\ 0.125 + 0.08 + 0.128 + 0.235 + 0.273 \\ 0.125 + 0.12 + 0.064 + 0.118 + 0.182 \\ 0.188 + 0.08 + 0.043 + 0.059 + 0.091 \end{vmatrix} = \begin{vmatrix} 0.3545 \\ 0.2637 \\ 0.1681 \\ 0.1217 \\ 0.092 \end{vmatrix}$$

Step 4: Comparison of alternatives

The normalized principal eigen vector is also called priority vector. Since it is normalized, the sum of all elements in priority vector is 1. In this example, priority vector for Supplier A is 35.45%, Supplier B is 26.37%, Supplier C is 16.81%, Supplier D is 12.17% and Supplier E is 9.20%. So, the most preferable Supplier is Supplier A who is having highest priority vector.

To check the consistency of the result, we need to find the principal Eigen value. Principal Eigen value is obtained from the summation of products between each element of Eigen vector and the sum of columns of the reciprocal matrix.

λ_{max} =2.67(0.3545) + 4.17 (0.2637) + 7.83 (0.1681) + 8.50 (0.1217) + 11 (0.0920)
= 5.4069 …. (4.2)

Now, Consistency Index (CI) needs to be found;

$$CI = \frac{\lambda_{max} - n}{n-1} \quad …. (4.3)$$

Here, λ_{max} = 5.4069 and the size of comparison matrix n = 5, thus the consistency index (C.I) is

$$CI = \frac{\lambda_{max} - n}{n-1} = 10.17\% \quad … (4.4)$$

After calculating the consistency index, we have to calculate Consistency Ratio (CR), which is a comparison between consistency index and Random Consistency Index (RI)

CR = CI / RI … (4.5)

The Random Consistency Index (RI) is given in Table 4.2.

Size of comparison matrix (n)	1	2	3	4	5	6	7	8	9	10
Random Consistency Index (RI)	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Table 4.7 Random Consistency Index (Satty 1990)

After calculating consistency ratio, if the value of consistency ratio is smaller or equal to 10%, the inconsistency is acceptable. If the consistency ratio is greater than 10%, there is a need to revise the subjective judgment.

In this example, CI = 0.1017 and RI for n = 5 is 1.12, and then

$CR = \frac{CI}{RI} = \frac{0.1017}{1.12} = 9.08\% < 10\%$. Thus, selection of Supplier A is Consistent.

Step 5: Calculate priority vector for alternatives

Products Similarly, the steps 2, 3 and 4 are performed for remaining

Step 6: Obtain overall priority vector

6. RESULT AND DISCUSSION:

The overall priority vector obtained as the result of AHP shows that Supplier A is suitable for the food industry product as shown in fig 6.1 which is represented graphically in Figure 6.1 So, supplier A is suggested as suitable supplier for Food industry product.

Table 6.1 Overall Priority Vector

	Quality	Quantity	Delivery time	Demand	Cost	Criteria	Overall Priority Vector
SA	0.4533	0.3554	0.4182	0.4249	0.4501	0.4159	**0.4191**
SB	0.2454	0.2695	0.258	0.2682	0.2918	0.2509	**0.2581**
SC	0.1718	0.1903	0.1599	0.1656	0.1204	0.1918	**0.1713**
SD	0.079	0.1314	0.098	0.0936	0.0919	0.0973	**0.0978**
SE	0.0506	0.0534	0.0659	0.0477	0.0458	0.044	**0.0537**
							1.0000

Fig 6.1 overall priority vectors for different criteria

The overall priority vector obtained as the result of AHP shows that Supplier A is suitable for the product Auto Adjuster. So, Supplier A is suggested as a suitable supplier for food processing product shown in the graph below.

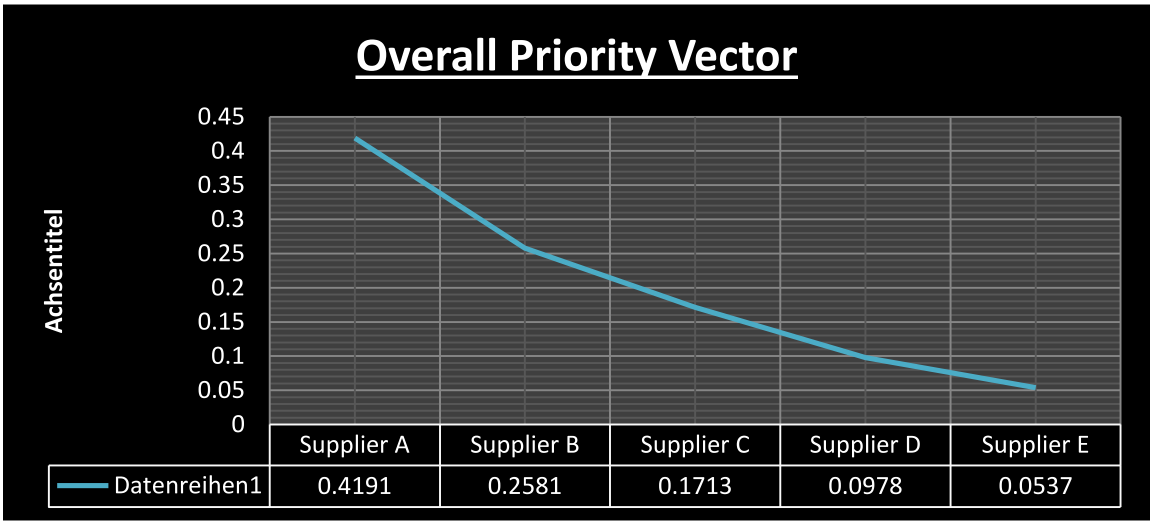

Fig 6.1 overall priority vectors for different criteria

7. CONCLUTION

In this chapter, detailed information on AHP, and its procedure, advantages, and applications, the application of AHP for selecting suitable supplier is done using MS-excel software. The overall priority vector of Supplier A obtained as the result of AHP for all the products is high as compared to other suppliers. So, it is suggested that Supplier A is the best for all the five Supplier of food industry products.

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