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Product Evaluation of Rijal Tashi Industry Pvt. Ltd. using Analytic Hierarchy Process

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Abstract

Selection of appropriate products is the key strategic consideration for supply chain operation. So, it is essential to use precision decision making tools for resolving selection problems. This study aims to present an analytic hierarchy decision making approach to evaluate the product of Rijal Tashi Industry Pvt. Ltd. The paper emphasizes multi criteria decision making approach and establishes the priorities for performance parameters of products. The product evaluation parameters are divided into 4 major criteria which are quality, variety, economy and effectiveness. These criteria are further classified into hierarchical sub-criteria. Criteria and sub-criteria are validated by the questionnaires distributed to group of experts from industries, sales and marketing. Pairwise matrix of criteria and sub-criteria are generated and weightage are assigned from the comparative results using Expert Choice Software. The alternatives for this research are squashes, vinegar, jam, pickle, ketchup, sauce and slice of fruits and vegetables. Result indicate that pickle is the more appealing product of case company which is followed by ketchup and sauce while squash is the least preferable product. Quality is the main criteria and customer satisfaction is the main sub criteria for product evaluation process. The research is limited to its sample size and the target people were majorly stakeholder of the case company who use these products.

Keywords

supply chain – analytic hierarchy – multi criteria decision – product evaluation – stakeholder – alternatives

1. Introduction

In today's competitive business environment, many organizations are planning to increase their market share so as to survive and to achieve sustainable growth. At the same time, these organizations must maintain its supply chain in a dynamic and rapidly changing business environment. The main challenges for the organization are how to evaluate the existing product and how to expand their distribution network for shiping those products to customers. In order to make the product available when the customer wants, strategic positioning of supply chain is essential [1]. This drives the manager to make decision in planning and controlling each part of their supply chain so as to take their business in desired direction. Analytic Hierarchy Process (AHP) is a multi-criteria decision making approach well suited for subjective judgments in selection process.

AHP identifies both the importance of weights for criteria and the ranking of existing product and potential distributors using stakeholder analysis.

Rijal Tashi Industry (P) Ltd. is the pioneers of packed food industries in Nepal which is well renowned for DRUK products. This industry was established in 1981. It is high tech venture of Tashi Commercial Corporation, Bhutan and Rijal Canning and Company, Nepal with technical collaboration with Bhutan Fruit Product, Bhutan. The products of the industries are squash, vinegar, jam, pickle, juice, ketchup, sauces and canned fruits and vegetables.

Nowadays, Rijal Tashi industry is facing problem in efficient flow of its products and it is gradually losing its control over suppliers. Figure 1 show how the production and sales of the case company fluctuated over the last 5 years. In year 2015, the total production of items decreases from 2638.67 MTS to 2465.41 MTS. Similarly, the sale of these items decreases from 2626.73 MTS to

2414.86 MTS. It is observed that there is 6.57% decrease in production and 8.10% decrease. Thus, it illustrates that the firm needs to select an appropriate products so as to improve its supply chain. Performance of the products not only leads to the benefit of the core enterprise but also enhances competitive performance by closely integrating the internal functions within a firm [2].

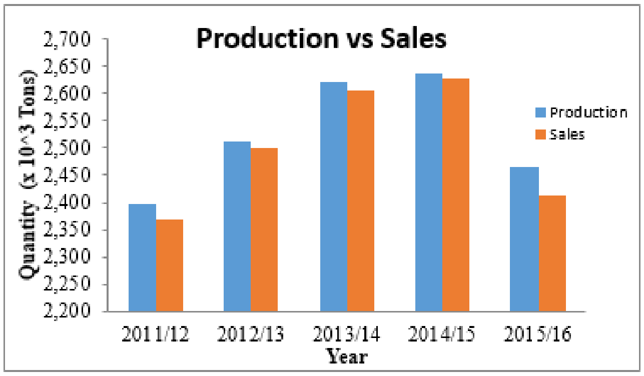

Figure 1: Production and Sales of Rijal Tashi Industry Pvt. Ltd.

So, with the motive to evaluate the performance of existing product, this research was designed so that it effectively links them with the external governing operations of supplier, customers and other channel members.This requires applying the analytical hierarchy process to illustrate the way transforming multiple criteria into effective supply chain management for long-run profitability.

2. Methodology

The research methodology is based on constructivist approach and case study type research strategy. A case study strategy is used for investigating a contemporary phenomenon within its real life context, when the boundaries between phenomenon and the context are not clearly evident, and in which the multiple source of evidence are utilized [3]. AHP framework in which hierarchical criteria and sub-criteria were determined from literature findings (published journal and articles) and pilot testing through experts opinion. The relevant information has been collected by questionnaire survey to determine the criteria and its importance through interviews, observations, document reviews and visual data analysis. Pair-wise comparison questionnaire were prepared for comparing each pair of the criteria, sub-criteria and alternatives used in the selection and to identify to what extent one criterion or alternative is more or less important or preferred to another. The respondents to this questionnaire were a committee of experts in the field of public purchasing. Their preferences are recorded in Saaty scale of 1-9, consistency ratio is checked for verification and weightage are generated.

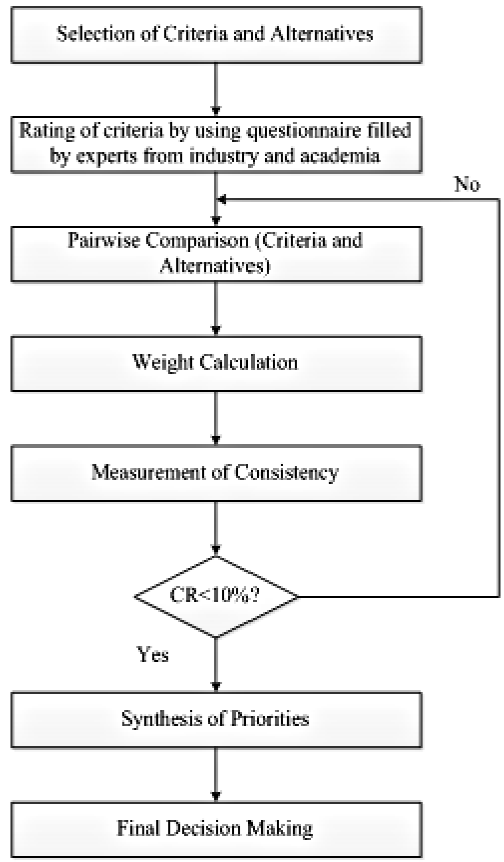

Figure 2: Schematic Representation of AHP Methodology

2.1 Analytic Hierarchy Process (AHP)

Analytic Hierarchy Process (AHP) was first introduced by Thomas Saaty [4] as an effective tool to deal with complex decision making. AHP is used for ranking various decision alternatives and selecting the best one [5]. The process starts by describing the problem in a hierarchical structure including in the highest level an overall (quantifiable) goal further decomposed in criteria and sub-criteria whereas in the lowest level alternative

Table 1: AHP approach

S.N.	Preference Weights	Definition	Explanation
1	1	Equally Preferred	Two activities contribute equally to the objectives
2	3	Moderately Preferred	Experience and judgment slightly favor one activity over another
3	5	Strongly Preferred	Experience and judgment strongly or essentially favor one activity over another
4	7	Very Strongly Preferred	An activity is strongly favored another and its dominance demonstrated in practice
5	9	Extremely Preferred	The evidence favoring one activity over another is of the highest degree possible of affirmation
6	2, 4, 6, 8, 9	Intermediates Values	Used to represent compromise between the preferences listed above
7	Reciprocals	-	Reciprocals for inverse comparison

solutions to attain the goal are found. The approach is applicable in situations where decision-makers and experts are available. The decision-makers needs to define the goal and can distinguish alternative solutions to attain it whereas experts are required to evaluate the alternative solutions based on criteria [6].

After structuring the problem, AHP is used to compute the weights for the different criteria. To do so, pairwise comparison matrices are constructed to assess how they contribute to the goal, starting from the first level of criteria and continuing to lower levels, comparing criteria on the same level under the same nod. Individual preferences are converted into ratio scale weights that generate linear additive weight for each alternative. All the criteria have been rated from scale 1 to 9 versus all other criteria, accordingly as stated in the Table. 1 [7]; [4]; [8]. Based on the ratings obtained through the questionnaire, matrixes are formed and the priorities are synthesized using the methodology of AHP. The decision maker compares the weightage given to several alternatives and selects the best alternative that meets the decision criteria. Numerical scores are assigned to rank each decision alternative based on how well the alternative meets the decision maker's criteria. [9] said that AHP is viable to formulate the desired decision making criteria, to determine the level of importance of different decision-making criteria, and to obtain the best decision. Generally, AHP has the following eight steps:

1. Define an unstructured problem and determine its goal.

2. Structure the hierarchy from the top (objectives from a decision-makers viewpoint) through intermediate levels (criteria on which subsequent levels depend) to the lowest level, which typically contains a list of alternatives.

3. Make a pair-wise comparison of elements in each group. [4] developed the fundamental scale for pair-wise comparisons.
   The pair-wise comparison matrix A, in which the element aij of the matrix is the relative importance of the ith factor with respect to the j^{th} factor, could be calculated as:

$$A = [a_{ij}] = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ 1/a_{12} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1/a_{1n} & 1/a_{2n} & \cdots & 1 \end{bmatrix} \quad (1)$$

   There are n(n-1)/judgments require developing the set of matrices in step 3. Reciprocals are automatically assigned to each pair-wise comparison, where n is the matrix size.

4. Hierarchical synthesis is now utilized to weight the eigenvectors according to weights of criteria. The sum is for all weighted eigen vectors corresponding to those in the next lower hierarchy level.

5. Having made all pair-wise comparisons, consistency is identified by using the Eigen value $\lambda_{\max}$, to

calculate the consistency index. [4] proposed that the largest Eigen value,

$$\lambda_{\max} = \sum a_{ij} \frac{W_j}{W_i}$$

Where,
$\lambda_{\max}$ is the principal or largest Eigen value of positive real values in a judgment matrix; Wj is the weight of j^{th} factor and Wi is the weight of ith factor.

6. Consistency test: Each pair-wise comparison contains numerous decision elements for the consistency index (CI), which measures the entire consistency judgment for each comparison matrix and the hierarchy structure. [4] utilized the CI and consistency ration (CR) to assess the consistency of the comparison matrix. The CI and CR are defined as,

$$CI = \frac{\lambda_{\max} - n}{n-1}$$

Where, n is the matrix size.

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

Where, the judgment consistency can be checked by taking the CR of CI with the appropriate value value,

Table 2: Average Random Consistency (RI)

Size of Matrix	Random Consistency
1, 2	0
3	0.58
4	0.9
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45
10	1.49

The CR is acceptable if it does not exceed 0.10. The CR is $>$ 0.10, the judgment matrix is inconsistent. To acquire a consistent matrix, judgments should be reviewed and improved.

7. Evaluate alternatives according to weighting.

8. Get ranking.

2.2 AHP Model

AHP hierarchy of goals, criteria, sub criteria and alternatives were generated from the literature review and pilot test from the survey questionnaires with the experts from industries and academia. The hierarchy for product selection is given in Figure 3.

2.3 Pairwise Comparison and Computations for Criteria

A survey questionnaire approach was used for gathering the data to assess the order of importance of the product evaluation criteria. From the hierarchy tree, we developed a questionnaire to enable pairwise comparisons between all the selection criteria at each level in the hierarchy. The pairwise comparison process elicits qualitative judgments that indicate the strength of a group of decision makers preference in a specific comparison according to Saaty's 1-9 scale. A group of experts from supply chain managers and academia was requested to respond to several pairwise comparisons where two categories at a time were compared with respect to the goal. Result of the survey questionnaire technique was then used as input for the AHP. It took a total of 6 judgments (i.e 4*(4-1)/2) to complete the pairwise comparisons shown in Table 3. The other entries are 1's along the diagonal as well as the reciprocalls of 6 judgments. The shown in the matrix can be deployed to derive estimate of the criteria priorities. The priorities provide a measure of the relative importance of each criterion. Essentially, the following three steps can be utilized to synthesize the pairwise comparison matrix.

1. Total the elements or values in each column.
2. Divide each element of the matrix by its column sum.
3. Determine the priority vector by finding the row averages.

Priority vector (Weights) of j^{th} factor W_j is obtained by row average as shown in Table 3. i.e, W1=0.5293, W2=0.0853, W3=0.1573 and W4=0.2281 where j=1, 2, 3 and 4.

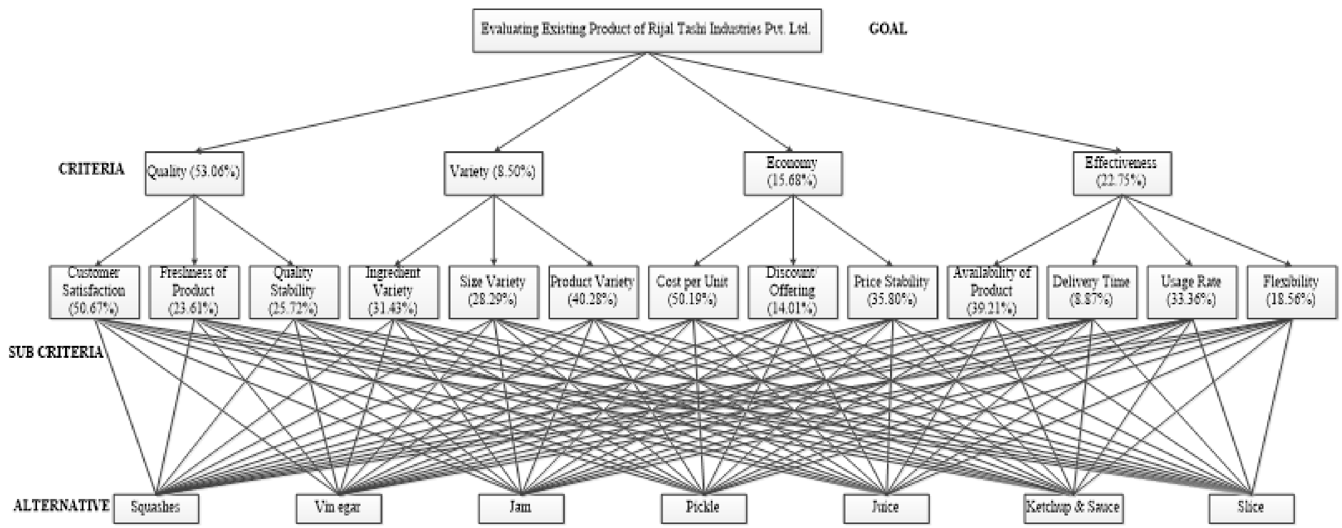

Figure 3: The Hierarchy for the Best Druk Product Selection Process

Table 3: Pairwise Comparison for Evaluating Criteria for the Best Product Selection

	Q	***V***	***E***	***Eff***
Q	1	5.46	3.24	2.77
V	0.18	1	0.57	0.31
E	0.31	1.77	1	0.70
Eff	0.36	3.21	1.42	1
Total	1.85	11.44	6.23	4.78

Table 4: Synthesized (or Normalized) Matrix for the Best Product Selection Criteria

	Q	***V***	***E***	***Eff***	***W***
Q	0.5405	0.4773	0.5201	0.5795	0.5293
V	0.0973	0.0874	0.0915	0.0649	0.0853
E	0.1676	0.1547	0.1605	0.1464	0.1573
Eff	0.1946	0.2806	0.2279	0.2092	0.2281

where,
Q = Quality
V = Varieties
E = Economy
Eff = Effectiveness
W = Weights

3. Result and Discussion

Product evaluation helps the business can improve it product to achieve success in competitive market. Weights of criteria and sub-criteria were also calculated upon pair-wise comparisons. The overall consistency ratio (CR) were than 0.1 (desirable value), so the model was validated. Priorities weights of sub-criterion is given in table 5.

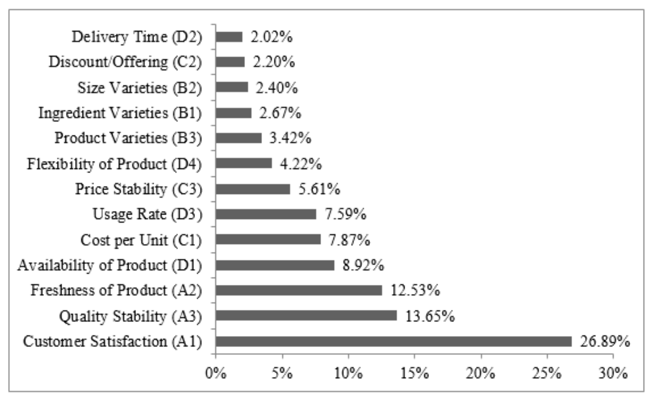

Figure 4: Priority Weights for Sub-Criteria for Evaluating the Products of Case Company

The criteria were breakdown into sub criteria where the weightage are shown in the figure. Customer Satisfaction were the most important sub criteria for evaluating the alternatives while Delivery Time contribute least for ranking the product. Normalized performance scores of the products are shown in the Figure 5 where products are ranked in the order from top to below. It depicts Pickle were performing better while Squashes were an underperforming product based on selected criteria and sub-criteria.

Table 5: Priorities of Sub-Criteria for Evaluating Existing Product

Sub-Criteria	Local Weightage
Customer Satisfaction (A1)	0.5067
Freshness of Product (A2)	0.2361
Quality Stability (A3)	0.2572
Ingredient Varieties (B1)	0.3143
Size Varieties (B2)	0.2829
Product Varieties (B3)	0.4028
Cost Per Unit (C1)	0.5019
Discount/Offering (C2)	0.1401
Price Stability (C3)	0.2849
Availability of Product (D1)	0.3921
Delivery Time (D2)	0.0887
Usage Rate (D3)	0.3336
Flexibility of Product (D4)	0.1856

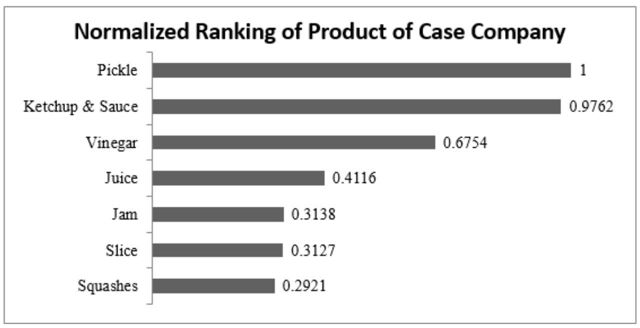

Figure 5: Normalized Ranking of the Products of Case Company

4. Conclusion

The research objective in this paper was developing a new framework for product evaluation of case company. Using AHP model, hierarchy structure for modeling the criteria and sub-criteria were developed based on literature and expert opinion, and the selected alternatives were compared based on pairwise comparison (Saaty). Different products were ranked at the end of the model to develop appropriate framework. The generated result shows that pickle is the most appealing product which is followed by ketchup and sauce, juice and vinegar. Squash is the least preferable product amongst the different alternatives. Quality is the main criteria that govern the evaluation process where customer satisfaction play essential role in its local weightage. The proposed framework of this research could help in planning, generating design alternatives, evaluation and selection. Through generated results, analyst can be able to decide which products are performing better and which need to be improved in different areas (criteria and sub-criteria). The model presented here can be further developed and modified to reflect different environment and supporting systems.

5. Recommendation

Future research could be continued to understand information system for the proposed framework that could help decision makers to perform very early evaluation and planning for product development process. Also, cost-benefit analysis of these products should be carried out in the future for improving the decision making process in product evaluation.

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