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Application of Analytic Hierarchy Process for Supply Chain Design Project

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***ABSTRACT*:**

Selection of best alternative among multiple alternatives is a tough task for decision makers in many industrial situations.This paper explores the applicability and capability of an outranking method known as Analytical Hierarchy Process (AHP) for selection of right alternative. The noveltyof the proposed methodology is its capability of dealing with both ordinal and cardinal information. The integrated approachis aeffective tool of the decision-making process in industrial environments. Five examples are illustrated toshow the effectiveness of method.The term "LAST-MILE" came from telecommunication industry and refers to final leg of the network. Last-mile delivery has become a critical source for market differentiation, encouraging retailers to invest in a myriad of consumer delivery innovations, such as buy-online-pickup-in-store, autonomous delivery solutions, lockers, and free delivery upon minimum purchase levels. Consumers care about last-mile delivery because it offers convenience and flexibility. For these reasons, same-day and on-demand delivery services are gaining traction for groceries. To meet customer needs, parcel carriers are increasing investments into urban and automated distribution hub. However, there is a lack of understanding as to how best to design last-mile delivery models with retailers turning to experimentations that, at times, attract scepticism from industry observers.

Keywords: Stakeholder Management, Feasibility study, Project Management Knowledge areas.

1Introduction

In a competitive industrial environment customer as well as manufacturers are becoming more conscious and inclined to demand a particular number of customized products at a particular speed. Therefore, it becomes important for the manufacturers to keep pace with dynamic conditions and rapid changes, be innovative, and adapt to new systems, techniques and methodologies. Because of all these factors, the industries and manufacturers have begun to make radical changes in their system and structures through cost reduction, by achieving higher economic benefit plus environmental benefit to maintain
their position in the global market.

The measurement of the efficiency level of a supply chain system is a very critical challenge. Mode selection, site selection, Flexible transport System selection, equipment selection, computer-integrated controlling system selection, AGV selection, facility layout selection, merchant selection,
process selection, information tool selection, channel partner
selection etc. are some of the major issues of supply chain management. The selection of right alternative makes a significant change in the productivity and profitability of the supply chain [1].

2 Case Company

Pepperfry is an online furniture and home decor marketplace based in India. Founded by former eBay executives AmbareeshMurty and Ashish Shah in 2011, the company's headquarters is located in Mumbai, India and has presence in 28 cities in India including Bengaluru, Delhi, Chandigarh, Pune, Noida, Gurugram, and others.

Pepperfry began operations in Mumbai in July 2011. The website Pepperfry.com was launched in January 2012. Pepperfry operates as a subsidiary of Trendsutra Platform Services Private Limited, a company based in Mumbai, India. In 2014, the company launched its mobile siteand apps for iOS and Android.

In the same year, Pepperfry opened its first offline store called Studio Pepperfry in Mumbai in 2014, and by 2019 there were over 65 stores across 28 cities in India. The company has three warehouses in India. One of them, in Hoskote area in Bengaluru, is spread across 360,000 square feet. In 2020, Pepperfry ventured into home interior partnering with Hettich, Bosch, Siemens, Kajaria, Gyproc, among others.

3 Literature Review

Supply Chain Management is a network of facilities that produce raw materials, transform them into intermediate goods and then final products, and deliver the products to customers through a distribution system. The basic objective of supply chain management is to "optimize performance of the chain to add as much value as possible for the least cost possible". In other words, it aims to link all the supply chain agents to jointly cooperate within the firm as a way to maximize

productivity in the supply chain and deliver the most benefits to all related parties.

3.1 Extending supply chains

Starting with Ford Motor Company's early attempts to manage supply chains, numerous opportunities and challenges in extending the boundaries of production and delivery have existed. However, the obstacles in understanding and reaping the potential benefits have left many firms unable to realize these opportunities. Recent developments in information technology and SCM techniques are diminishing these obstacles, and are allowing managers to uncover both subtle and evident outcomes of their strategies. The power of these techniques has been manifested in firms, such as Dell Computer Corporation, seeking to manage channels of supplypreviously untenable. Last-mile supply chains - The past decade has seen a host of firms seeking to extend their supply chains directly to the end customer. Managing this portion of the supply chain – homedelivery service for the customer –has been termed the "last-mile" issue and has been a particular problem from a logistics infrastructure standpoint, most notably because of trade-offs between routing efficiency and customer convenience. Another issue, which firms must address when extending their supply chains to the last-mile, comes from the consumer standpoint. Specifically, the method by which consumers place orders can have a significant impact on transaction costs and customer service. A successful last-mile supply chain initiative therefore seems to require attention to the customer order cycle. Online grocery. A particularly interesting area of last-mile research is the advent of online grocers. This industry's attempt at extending the supply chain demonstrates how a traditional, frequently performed action by consumers can be transformed through the use of an e-commerce platform. Traditional retailers recognized the "live" store-customer interface as a critically important element of the business. For instance, "off-line" grocers in traditional settings have tried to add-value by improving retail layout, item availability, store atmosphere, and product assortment.[4]

3.2 E-commerce

The current growth and popularity of e-commerce has affected many consumers everyday lives by providing a wider range of choices, more available information and Last-mile supply chain efficiency provides ease of purchasing. Simultaneously, retail firms have gained advantages by adopting e-commerce platforms through more efficient delivery of services and greater access to new consumer markets. How retailers traditionally interact with customers has been studied from the retail and distribution literature, but investigations into the customer-retailer electronic interface have emerged from the HCI and marketing fields.

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4 Research Design

To meet the research objectives four research tasks will be carried out mainly through literature review, questionnaire and then analyzing the data. This is graphically presented as below:

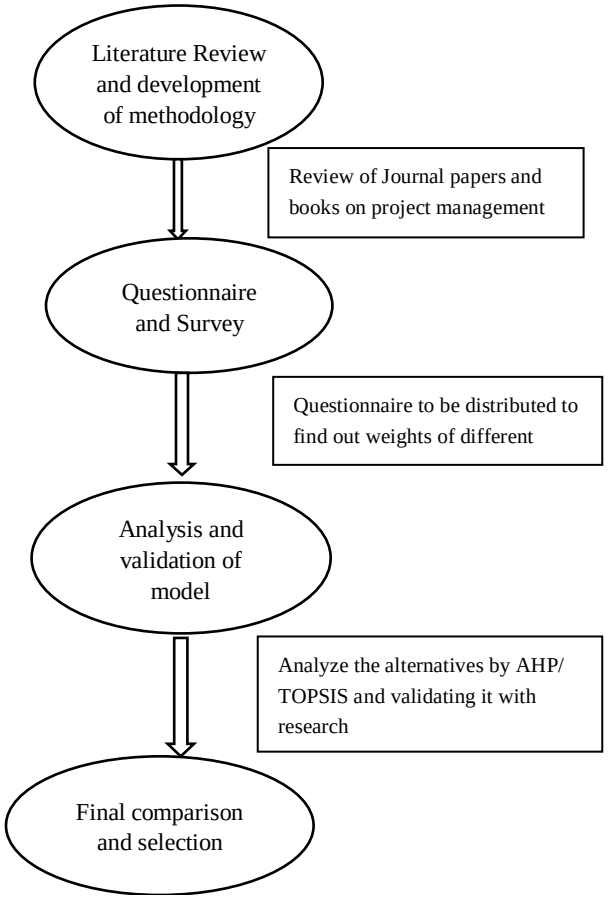

Figure 4.1 - Research Methodology

5 Strategies & Criteria's

5.1 Strategies

A. Distribution Facility

In this the supply chain is design consist of multiple built-up facilities. Through this facilities product flow takes place from supplies to end customer. Product is stored in different facilities for a particular time period. Product handling is more because of multiple loading-unloading, storing-retrieval activities. Hence the chances of product getting damaged are more.

B. Terminal

In this supply chain design consist of single facility in the downstream. From this facility products are sent to end customers. Instead of storing at last mile crossing is involved in which group of products are transferred from large container to small distribution vehicle. As there is very less direct handling of products chances of damage are comparatively less.

C. Hybrid

As name indicated it is the combination both the above strategies. It overcomes the operational cons of above strategies. In terminal case there is operational challenge during reverse logistics. And in facility case there are high chances of damages. But in hybrid case both the capital cost and operational cost are high.

5.2 Criteria's

1. Cost

It is the major driving factor for decision making. Facility cost is more compared to terminal as it is open plot. Also, the there is no warehousing operational cost at last. But in terminal strategies there is high capital cost. It requires scissor lift for crossing, trolleys for product grouping etc.

2. Stability

Stability of supply chain with demand fluctuations is one the major factor while designing supply chain. Supply chain designed should be flexible enough to handle demand fluctuations such seasonal, dry period etc. Also, there should be stability in assets and/or equipment's involved in supply chain such as land agreements, supplier etc.

3. Distribution

As in terminal case we group products according to delivery locations which brings constraints while distributing products. Hence it may reduce efficiency of supply chain. Even hybrid strategy won't overcome this challenge.

4. Labor Risk

While implementing new strategy there is always change in head count especially blue color ones. Management has to face labor unions and other stakeholders while making such changes.

6 Data analysis & Results

Selection of idea/concept is very crucial to obtain objective of project. Many parameters such as financial, risk, benefits, future opportunities, etc. need to be consider.

The Analytic Hierarchy Process (AHP) developed by Saaty provides an elastic and easy way of analyzing factors. It is a multicriteria decision-making procedure that allows subjective along with objective factors to be considered. It allows the participation of decision makers (managers) in reaching agreement.

There are seven steps for applying AHP (Saaty, 1980):

1. Problem definition and determination of goals.
2. Structuring of the hierarchy of all the criteria of selection.
3. Constructing a set of pair-wise comparison matrices.
4. There are n*(n-1) judgments required to develop the set of matrices in step 3. Reciprocals will be assigned in each pair-wise comparison.
5. Weights for each criterion are calculated and eigen values are determined.
6. After completing all the pair wise comparisons we then find the consistency and it should be below 10 percent.
7. Steps 3-6 are achieved for all levels in the hierarchy structure.

In this method, predilections between options are determined by making pair wise comparisons matrices. The person choosing between options prioritizes one over the other using a predetermined scale of number. Saaty provided a scale range of 1-9 to prioritize, meaning 9 is the best option and 1 indicates not suitable. Table indicates the pair-wise scale used here.

In order to apply this method, we now need the basis of our selection or the priority vectors that would govern the selection of tool. the following selection vectors are determined [9]:

Rating	Prioritization
9	Extremely preferred
8	Very strongly to extremely
7	Very strongly preferred
6	Strongly to very strongly
5	Strongly preferred
4	Moderately to strongly
3	Moderately preferred
2	Equally to moderately
1	Equally preferred

Table 6.1 - Rating Scale used for AHP

Based upon the above-mentioned parameters, the experts provided a ranking on a scale of 1-9. The next step is to prepare a Pair Wise Comparison Matrix (A) as below:

$$A = \begin{array}{c} \\ C_1 \\ C_2 \\ C_3 \\ C_4 \\ C_5 \\ C_6 \\ . \\ C_n \end{array} \begin{array}{c} \begin{array}{cccccccc} C_1 & C_2 & C_3 & C_4 & C_5 & C_6 & . & C_n \end{array} \\ \begin{bmatrix} 1 & a_{12} & a_{13} & a_{14} & a_{15} & a_{16} & . & a_{1n} \\ a_{21} & 1 & a_{23} & a_{24} & a_{25} & a_{26} & . & a_{2n} \\ a_{31} & a_{32} & 1 & a_{34} & a_{35} & a_{36} & . & a_{3n} \\ a_{41} & a_{42} & a_{43} & 1 & a_{45} & a_{46} & . & a_{4n} \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 & a_{56} & . & a_{5n} \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & 1 & . & a_{6n} \\ . & . & . & . & . & . & 1 & . \\ a_{n1} & a_{n2} & a_{n3} & a_{n4} & a_{21} & a_{21} & . & 1 \end{bmatrix} \end{array}$$

Figure 6. 1- Generic Pair Wise Comparison Matrix

n = selection vector number to be weighed
Ci = ith selection vector,
aij = weight of ith criteria according to jth criteria
The next step is to calculate (λmax) so as to lead to the Consistency Index and the Consistency Ratio [10].
The formula of Consistency Index (CI) as follows:

$$CI = (\lambda max - n)/(n - 1)$$

Consider [Ax = λmax * x] where x is the Eigenvector.
Then the Consistency Ratio (CR) is assessed in order to measure the rate of consistence of the judgments, comparative to substantial samples of indiscriminate judgments. If CR is greater than 0.1 then the judgments are unreliable [8].
The Pair-wise Comparison formed by interviewing experts is:

ItemDescription	Cost	Stability	Distribution	Labour Risk
Cost	1	1/5	3	4
Stability	5	1	9	7
Distribution	1/3	1/9	1	2
Labour Risk	1/4	1/7	1/2	1

Figure 6.2 - Pair Wise Comparison Matrix

Once this comparison is complete, the numbers from the matrix in Figure are used to get a priority value for each vector. To do this, we have to normalize the matrix (as shown in Figure 5.2) by dividing each element of the matrix with its respective column total.

ItemDescription	Cost	Stability	Distribution	Labour Risk
Cost	0.1519	0.1376	0.2222	0.2857
Stability	0.7595	0.6878	0.6667	0.5000
Distribution	0.0506	0.0764	0.0741	0.1429
Labour Risk	0.0380	0.0983	0.0370	0.0714

Figure 6.3 - Standardized Matrix

Lmax	4.15638631
CI	0.05212877
RI	0.89
CR	0.05857165

Figure 6.4 - Results of AHP process

The last step in AHP is to attain the ranking of the 3 strategies by combining the two matrices from Figures 4.7 and 4.8. Let us denote the matrix in Figure 4.7 as A and the matrix in Figure 4.8 as B. The ranking is attained by multiplying the two matrices, A*B. Figure 4.9 confirms the ranking of the tools.

Strategy	VALUE	RANK
A. Distribution Facility	0.2478	3
B. Terminal	0.4300	1
C. Both	0.3222	2

Figure 6.5 - Final Selection of strategy

7 Conclusion

The use of AHP in decision making allows the decision maker to assign the values of relative importance to the attribute based on his/her preferences. The score calculated by the method evaluate and rank the alternatives and lead to selection of a suitable alternative.

The major steps completed in current work are: Interviews were held with industry experts and criteria for the AHP method were determined based upon these. AHP suggested Terminal strategy is best fit for given scenario. Cons of these strategy can be overcome by adopting technology and innovation.

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