

Selecting Suppliers in the Paper Industry in Evaluation of Enterprise Modelling

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Abstract: AHP avoids the arbitrary assignment of weights for the factors distressed by the decision-maker, which aftermath in extra precise evaluation of the vendor. Also, the belief of comparative pair astute analogy has been utilized amid every two alternatives, and two factors made this vendor locale method the best one in the present company environment. The criteria ranking is determined Cost, Safety environment concern, Production facilities and capacities and quality, worth from the most important to the least important. This paper uses AHP methodology to ascertain the best supplier for buying paper in the paper industry. The multi-criteria choice making is a crucial instrument in fathoming the supplier choice issue. It permits the leaders to rank the applicant option more productively and effortlessly. The outline of the case gives the computational methodology of the AHP. The outline and findings of the study show how a few elements in the supplier choice and assessment criteria influence the purchaser's choice.

Keywords: AHP, Paper Industry, Factor Analysis, Decision making.

1. Introduction

In this period of globe contest, the companies realize the importance of selecting a competitive supplier and choosing different procedures to find a perfect supplier as per their need [2-3]. Additionally, suppliers are a vital constituent of any supply chain [9]. The skill and presentation of suppliers mainly ascertain the accomplishment or wreck of the supply chain management system. Supplier selection procedure plays a vital act and momentous encounter on buying association in the supply chain [10-12]. Nowadays, the creation of supplier selection procedure is one of the main portions of decisions in supply shackle management. As there are countless suppliers with countless criteria of selection from the buyer side, scholars have utilized disparate methods, variables, criteria, and factors to select the best suitable suppliers per buyer need [13]. To pick the right supplier, distinctive routines can be utilized. In this paper, we utilized AHP to focus on the best supplier in the paper industry [14].

1.1 Analytical Hierarchical Process (Ahp): As Multiple Criteria Decision-Making Tool:

AHP, as its conception, is one of the most extensively utilized criteria decision-making tools [15]. Different scholars encompass demands of AHP in disparate fields such as arranging, selecting the best alternative, resource allocations ascertaining clashes, optimization, etc., and numerical expansions of AHP [16]. AHP offers an approach to rank option blueprints considering leaders' judgement concerning the significance in both the criteria and the degree for meeting every option.

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Consequently, AHP is suitable for the supplier choice issue [17]. The issue chain of importance fits an examination considering the effect of a particular level on any larger amount. The methodology starts by deciding the relative significance of the criteria in meeting the objectives. At long last, the after-effects of the two investigations are integrated to figure out the relative significance of the choices in meeting the objective [18]. AHP is based on Eigen pairwise comparison, which measures qualitative and quantitative performance [19].

2. Literature Review:

Tahriri, Osman, Ali, & Yusuff [7] Supplier determination techniques are the models alternately methodologies used to direct the choice process. The strategies picked are amazingly critical to the general choice preparation and can significantly impact the choice results. It is imperative to get why a firm picks one strategy (or a blend of distinctive systems) over another [7]. The supplier selection procedure is to cut buy chance, giving purchaser maximum also finished it aims at developing closeness and long-term connections between clients and suppliers [20]. The AHP is moderately easy to utilize and get it. This strategy fuses subjective also quantitative criteria. A survey of the supplier choice writing demonstrates that the AHP strategy stands out among the most regularly connected routines, practically speaking [21-23]. AHP is a perfect strategy for positioning choices when various criteria and sub-criteria are exhibited in the choice making methodology [1]. Assessed suppliers based on 18 criteria based on the online AHP framework where suppliers needed to enrol and enter their throwing particulars. Muralidharan, Anantharaman, & Deshmukh [4] proposed nine evaluating criteria on a five-step AHP-based model for selecting suppliers and involved people from the store, quality, and purchase [24-25]. Chan [2] built up an intuitive choice model with AHP to encourage leaders in selecting suppliers based on the chain of communication without any involvement of human judgement. This model of AHP consisted of six assessing criteria and 20 sub-variables [5].

They developed an AHP-based choice-making way to deal with taking care of the supplier determination issue [26-27]. Potential suppliers were assessed in light of 14 criteria. The AHP was presented. There has been wide examination of this strategy's exact adequacy and hypothetical legitimacy [28]. Like the MAUT, AHP permits the leader to structure confounded issues as a choice pecking order [29-33]. For the most part, the pecking order comprises three distinctive levels, which incorporate objectives, criteria, and choices [34]. AHP is frequently considered a supplier choice strategy because it permits choice creators to rank suppliers in light of the relative significance of the criteria and the suitability of the suppliers. Vaidya & Kumar [8] have composed a magnificent survey and indicated the rate utilization of the AHP technique amid the predefined periods [6]. A few supplier positioning methodologies were mulled over or created for supplier determination, and methodologies were created [35-39].

3. Research Methodology:

3.1 Purpose of Research:

The research aimed to examine the criteria for selecting the supplier and evaluating them in the paper industry using Analytical Hierarchy Process [40]. A questionnaire to 140 buyers in the paper industry across India was selected, and they have to rank 40 items on a scale of 5 from 1 to 5.

The main criteria included in the questionnaire are:

- Competitive Price: It is the price offered by other competitors of the supplier.
- Product Price: It is the product's actual price that a supplier offers to the buyers.

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- **Payment Terms:** It is defined as the payment terms that a supplier asks the buyer, which can be credit/debit.
- **Logistics Price:**
- **Product durability:** How much is the product's actual life is meant by product durability.
- **Product performance and conformance to standards:** It explains the use of the product according to the specified standards defined by the buyer.
- **Total Quality Management:**
- **Addressing customer feedback:** It states how seriously the suppliers take the feedback from customers.
- **Marketing:** It explains the Marketing resource of the supplier.
- **Marketability:** It explains the marketability of the product.
- **On-time delivery:** The capacity of a business to satisfy delivery orders
- **Delivery Schedule:** Timing or rate of conveyance as needed by a purchaser, or as concurred between a purchaser and a vendor, for products or administrations obtained for a future conveyance period.
- **Minimum Safety Stock Compliance:** Stock held as support against confound in the middle of the gauge and real utilization of interest, in the middle of expected and genuine conveyance time, and unforeseen crises. Additionally, called store stock.
- **Flexibility to production changes:** Capacities and procedures for recognizing and getting ready process or any changes in limit or volume.
- **Communication system:** It defines how well the suppliers' communication system is. Having solid correspondence while taking care of the issue and between different suppliers happens because of trust. Furthermore, it is normal to have a solid correspondence between the firm's client in advertising and taking care of the procedure.
- **Responsiveness:** The capability to regulate rapidly to abruptly changed external circumstances.
- **Work Experience:** The knowledge and the competence that one increases while doing a meticulous job.
- **Financial stability of the supplier:** the supplier is in great financial condition.
- **Impression:** Opinion about the supplier.
- **Amount of past business**
- **Emergency:** Supplier capacity to fill buyer's emergency orders.
- **Service after sale:** Periodic and necessary maintenance of product by the supplier.
- **Process Flexibility:** The different sets of products a system can generate.
- **Volume Flexibility:** The effortlessness to enlarge or decrease the result of an accessible system.
- **JIT Concept:** strategic stock organizations spend to raise efficiency or reduce waste by getting products only as required in the process.
- **Handling and packaging capability:** It defines the supplier's ability to handle the products before

they are delivered to the buyers and how well suppliers can package the products.

- Storage Space defines the supplier's capacity to store the material/ products, basically how well suppliers can maintain their inventory.
- Production Capacity of the supplier: it is about the capacity of suppliers to produce the paper to meet the buyer's needs and requirements.
- Sharing of sensitive information: How well suppliers can share the necessary information about the products (paper, in this case) to the buyers.
- Workforce/ physical size: It defines the actual manpower employed in the organization.
- Reputation/ Position in the industry: the beliefs held up about someone in the market.
- Response to new improvements/ systems
- Design Capability: Designing capacity of the supplier.
- Technology and Innovativeness: Using new and innovative technology to produce the product and meet the buyer's needs and requirements in this fast-moving economy.
- Usage of PPE's (Personal Protective Equipments)
- Product Variety: the ability of the supplier to give buyer's variety of products with different characteristics so that buyers can choose from a variety of products.
- Incident & Accident Records
- Environmental Cost
- Environment management system
- Training aids

Identify a qualitative interview of 10 major buyers of the paper industry to draw out the important problems and opportunities buyers face while selecting their suppliers [41-46]. In this study, the questionnaire was designed to keep the target group, the suppliers of the paper industry. They are responsible for establishing an effective supply chain system and prop the output of organizations [47-51]. We used reliability analysis, factor analysis, and the AHP method to evaluate the factors obtained after factor analysis [52-57].

4.Data Analysis:

4.1 For Supplier Selection

4.1.1 Reliability Analysis

To check the supplier selection and evaluation questionnaire is reliable, we have first checked Cronbach's alpha [58-67]. A high level of Cronbach alpha tells internal consistency among multiple and scale is reliable (table 1).

Table 1: Cronbach's alpha for Supplier Selection and evaluation in the paper industry

| Cronbach's Alpha | No. of Items |
|------------------|--------------|
| 0.987 | 140 |

Our Cronbach's alpha is **0.987**, a measure of a high level of internal consistency for scale in the sample related to supplier selection [68].

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4.1.2 Factor Analysis

Factor analysis was done to reduce all the criteria to lesser factors [69]. The Principal components factor analysis with varimax rotation was done to extract factors and gain a better interpretable factor matrix [70-75]. With few special cases, variables had component loadings of 0.50. The 40 criteria were diminished to thirty-five basic elements, six factors [76]. Table 2 shows the factor analysis for supplier selection, where thirty-five elements are grouped under six factors, i.e., Management & Organization, Delivery Compliance, Cost, Quality, Production facilities & capacities and Safety & environmental concern [77-79].

Table 2: Factor analysis of supplier selection

| | Cronbach's alpha | Mean | Standard Deviation | Factor Loadings |
|--|---------------------|------------------------|-----------------------|--------------------|
| Factors | | | | |
| I: Management & Organization | | | | |
| Design Capability | 0.949 | 3.17 | 1.152 | 0.789 |
| Technology Innovativeness | | 3.22 | 1.134 | 0.734 |
| Response to new improvements/ systems | | 3.02 | 1.050 | 0.703 |
| Product Variety | | 3.14 | 1.084 | 0.702 |
| Training aids | | 3.05 | 1.109 | 0.688 |
| Production Capacity | | 3.22 | 1.074 | 0.620 |
| Financial Status of the Supplier | | 3.23 | 0.998 | 0.608 |
| Amount of past business | | 3.22 | 1.107 | 0.571 |
| Usage of PPE's | | 3.24 | 1.084 | 0.551 |
| Work experience | | 3.07 | 1.073 | 0.545 |
| Sharing of Sensitive information | | 3.04 | 1.038 | 0.545 |
| Process Flexibility | | 3.33 | 1.123 | 0.540 |
| Workforce Size | | 3.17 | 1.050 | 0.516 |
| Service after-sale | | 3.22 | 1.030 | 0.509 |
| | | Total Variance 20.352% | | |
| II: Delivery Compliance | | | | |
| On-time delivery | 0.903 | 3.30 | 1.169 | 0.740 |
| Impression | | 3.54 | 1.147 | 0.641 |
| Marketability | | 3.27 | 1.1091 | 0.635 |
| Minimum Safety stock compliance | | 3.42 | 1.119 | 0.629 |
| Flexibility to production changes | | 3.38 | 1.115 | 0.585 |
| Delivery Schedule | | 3.33 | 1.148 | 0.559 |
| Communication Systems | | 3.19 | 1.008 | 0.541 |
| | | Total Variance 14.075% | | |
| III: Cost | | | | |
| Competitive Price | 0.817 | 3.17 | 0.985 | 0.748 |
| Marketing | | 2.93 | 1.125 | 0.685 |
| Payment Terms | | 3.01 | 0.978 | 0.672 |
| Product Performance and conformance | | 2.97 | 1.171 | 0.660 |

| | | | | |
|---|------------------------|------|-------|-------|
| to standards | | | | |
| Logistics Cost | | 3.02 | 0.922 | 0.597 |
| | Total Variance 11.867% | | | |
| IV: Quality | | | | |
| Total Quality Management | 0.694 | 2.99 | 0.904 | 0.739 |
| Addressing feedback from customers | | 3.25 | 1.139 | 0.706 |
| Reputation | | 3.36 | 0.995 | 0.547 |
| Product Price | | 3.20 | 0.990 | 0.529 |
| | Total Variance 7.104% | | | |
| V: Safety and Environment Concern | | | | |
| Incident/accident records | 0.550 | 3.30 | 1.080 | 0.769 |
| JIT concept | | 3.12 | 1.176 | 0.633 |
| Environment Management System | | 3.14 | 0.994 | 0.513 |
| | Total Variance 5.770% | | | |
| VI: Production Facilities and Capacities | | | | |
| Product durability | 0.642 | 2.90 | 1.044 | 0.639 |
| Storage Space | | 3.30 | 1.113 | 0.491 |
| | Total Variance 5.734% | | | |

Quality: For any buyer, quality means total quality management, which considers the best product price, addressing all feedback of customers [80]. Every buyer wants that supplier to maintain the best quality as per customers' need at the best price [81-85].

Delivery Compliance: Meeting delivery compliance is one of the most important parameters for any buyer [86-91]. He would like to have on-time delivery at the scheduled time, and delivery can be maintained as per production plan change, and the buyer must also maintain a minimum stock of goods [92].

Management & Organization: Every buyer would like to keep in the account after-sale service how much flexibility in the process, verity and capacity in production, design capacity, and improvement by technology innovations. Buyers also need to see supplier is not sharing their information with someone [93].

Cost: Every buyer wants that there should be a flexible payment term at a minimum logistic cost but a competitive price [94-98]. Despite all cost considerations product must meet the required standards [99].

Production Facilities and Capacities: Every buyer wants to know how suppliers normally store the product inventory as product storage affects product quality and durability [100].

Safety & Environment Concern: In the production of any product, any wrong incidents or accidents play any important role as a greater number of such incident negatively impact on the goodwill of the company [101-103]. Nowadays, most manufacturing companies have to follow an environmental management system as for most buyers now, and Environmental issues are deciding factor [104].

4.2 For Supplier Evaluation

AHP, grew by Saaty, delivers how to focus the relative significance of an arrangement of exercises in a multi-criteria choice issue [105]. The procedure makes it conceivable to join judgments on elusive, subjective criteria close by unmistakable quantitative criteria. The AHP technique considers three

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standards: first and foremost, pairwise comparison matrix; second, a syncretization of the options and the criteria; third, a combination of the needs (table 3).

Table 3: Pairwise Comparison for supplier selection

| | Management & organization | Delivery Compliance | Cost | Quality | Safety & Environment Concerns | Production facilities and capacities |
|--------------------------------------|---------------------------|---------------------|------|---------|-------------------------------|--------------------------------------|
| Management & organization | 1 | 3 | 2 | 2 | 2 | 2 |
| Delivery Compliance | 1/3 | 1 | 1/4 | 1/4 | 1/4 | 1/4 |
| Cost | 1/2 | 4 | 1 | 1/2 | 1/2 | 1/2 |
| Quality | 1/2 | 4 | 2 | 1 | 1/2 | 1/2 |
| Safety & Environment Concerns | 1/2 | 4 | 2 | 2 | 1 | 1/2 |
| Production facilities and capacities | 1/2 | 4 | 2 | 2 | 2 | 1 |

Table 4: Priority Vector for supplier selection

| | Management & organization | Delivery Compliance | Cost | Quality | Safety & Environment Concerns | Production facilities and capacities | Priority |
|--------------------------------------|---------------------------|---------------------|------|---------|-------------------------------|--------------------------------------|----------|
| Management & organization | 1 | 3 | 2 | 2 | 2 | 2 | 0.727 |
| Delivery Compliance | 1/3 | 1 | 1/4 | 1/4 | 1/4 | 1/4 | 0.049 |
| Cost | 1/2 | 4 | 1 | 1/2 | 1/2 | 1/2 | 0.117 |
| Quality | 1/2 | 4 | 2 | 1 | 1/2 | 1/2 | 0.146 |
| Safety & Environment Concerns | 1/2 | 4 | 2 | 2 | 1 | 1/2 | 0.181 |
| Production facilities and capacities | 1/2 | 4 | 2 | 2 | 2 | 1 | 0.225 |

Priority vector is normalized main Eigenvector, and the sum of all agents in priority vector is 1, which displays comparative weights amid the things that we difference. From Table 4, the most important criterion in the supplier selection process is management & organization with a priority of 0.727, production at second rank with a priority of 0.225, followed by Safety and Environment Concern with a priority of 0.181 and Delivery Compliance has the least importance with a priority of 0.049.

In AHP, the consistency ratio measures the pairwise consistency and if CR is 0.10 or less means pairwise comparison is reasonable, and we continue with the AHP process.

$$\lambda_{\max} = 6.1528$$

$$\text{Consistency Index} = 0.030$$

$$\text{Consistency Ratio} = 0.030/1.24 = 0.024$$

4.3 Other Pairwise Comparison for The Supplier Selection

Table 5 shows the summary of the Suppliers' pairwise comparisons that the Decision-maker provided for each criterion of the supplier selection problem. Using this table 5 and referring to selected pairwise comparison entries, we see that the Decision-maker stated the following preferences:

Using the pairwise comparison matrices in Table 5, many other insights may be gained about the preferences Decision maker expressed for the suppliers.

Table 5: Comparison Matrices Showing Preferences for the Suppliers using each factor

| Management & Organization | Supplier A | Supplier B |
|---------------------------|------------|------------|
| Supplier A | 1 | 1/2 |
| Supplier B | 2 | 1 |

| Delivery compliance | Supplier A | Supplier B |
|---------------------|------------|------------|
| Supplier A | 1 | 2 |
| Supplier B | 0.5 | 1 |

| Cost | Supplier A | Supplier B |
|------------|------------|------------|
| Supplier A | 1 | 6 |
| Supplier B | 0.166 | 1 |

| Quality | Supplier A | Supplier B |
|------------|------------|------------|
| Supplier A | 1 | 0.33 |
| Supplier B | 3 | 1 |

| Safety & Env. Concern | Supplier A | Supplier B |
|-----------------------|------------|------------|
| Supplier A | 1 | 6 |
| Supplier B | 0.166 | 1 |

| Production facilities & Capacities | Supplier A | Supplier B |
|------------------------------------|------------|------------|
| Supplier A | 1 | 2 |
| Supplier B | 0.5 | 1 |

In all cases, we analyzed that supplier B is preferred over supplier A in all factors.

Overall Priority of Supplier A:

$$(0.727 \times 0.33) + (0.049 \times 0.33) + (0.117 \times 0.741) + (0.146 \times 0.33) + (0.181 \times 0.249) + (0.225 \times 0.33) \\ = .23991 + .01617 + .086697 + .04818 + .045069 + .07425 \\ = 0.510$$

Ranking these priorities, we have the AHP ranking of the decision alternatives, and Supplier B has priority over supplier A (table 6 and figure 1).

Table 6: The AHP Result

| | |
|------------|-------|
| Supplier A | 0.510 |
| Supplier B | 0.908 |

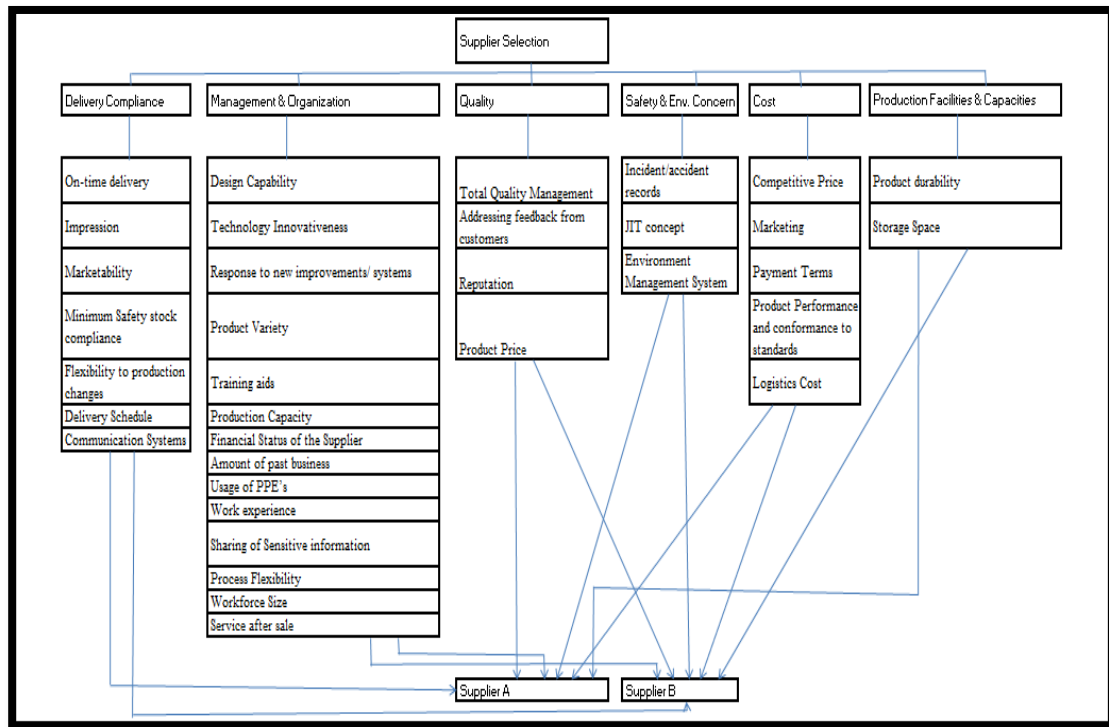


Figure 1: Hierarchical structure for Supplier Selection

5.Conclusion:

Determination of the wrong supplier gives a tremendous misfortune to the association. It is imperative to choose the most proper supplier for a modern application. The issue of supplier determination is vital. The introduced study investigates the utilization of the AHP technique in illuminating a supplier choice i. The the outcogot can be important to the leader in confining the supplier choice methods. The multi-criteria choice making is a crucial instrument in fathoming the supplier choice issue. It permits the leaders to rank the applicant option more productively and effortlessly. The outline of the case gives the computational methodology of the AHP. The outline and findings of the study show how a few elements in the supplier choice and assessment criteria influence the purchaser's choice.The ranking of the factors is determined Management & Organization- Production facilities & capacities- Safety and Environment Concern- Quality- Cost-Delivery Compliance from the very important to the very negligible.

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