CHAPTER 3

ANALYTICAL NETWORK PROCESS AND ITS APPLICATION FOR SUPPLIER SELECTION

3.1 INTRODUCTION - ANALYTICAL NETWORK PROCESS

The Analytical Network Process (ANP) is a more general form of the analytic hierarchy process used in multi criteria decision analysis (Saaty 1998). AHP structures a decision problem into a hierarchy with a good decision and alternatives, while the ANP structures the problem as a network. Both AHP and ANP then use a system of pairwise comparison to measure the weights of the components of the structure and finally to rank the alternatives in the decision.

Many decision problems cannot be built as hierarchial because of dependencies (inner / outer) influences between and within clusters (criteria, alternatives). ANP is very useful to solve this kind of problems. ANP provides a general framework to deal with decisions without making assumptions about independence of higher – level elements from the lower and about the independence of the elements within a level. In fact ANP uses a network without the need to specify levels as in a hierarchy.

ANP is firstly introduced by Saaty, which is based on 1 – 9 scale, in his book named “The Analytic Hierarchy Process” (1980). After that, Saaty developed this issue in his published book named “The Analytic Network Process” (1998). Saaty suggested the usage of AHP to solve the problem of independence of alternatives or criteria and the usage of AHP to solve the
problem of dependence among alternatives or criteria. The ANP Network is shown in Figure 3.1 which is the simple and special case of Network.

![Figure 3.1 Structure of ANP](image)

The ANP Network is shown in Figure 3.1 which is the simple and special case of Network.

Nodes represent components of the system, arcs denote interactions between them. In order to build the decision problem, all interactions among the elements should be considered. As it is seen from Figure 3.1 that X -> Y means that the elements of a components Y depends on Components X.

The control hierarchy, critical for ANP analysis, provides overriding criteria for comparing each type of interaction that is intended by the network representation.

The Control Hierarchy, Critical for ANP analysis, provides overriding criteria for comparing each type of interaction that is intended by the network representation. There are two types of control Criteria.

- A control criterion may be directly connected to the structure as the goal of a hierarchy if the structure is in fact a hierarchy. In this case the control criterion is called a comparison – “linking” criterion.

- Otherwise a control criterion does not connect directly to the structure but “induces” comparisons in a network”. In this
In this work the scope of this research paper, the second control criteria (a comparison – “inducing” criterion) is chosen according to the relationship between criterias and alternatives.

In the application of ANP, software like, Ecnet, Super Decision or Mathematical Program, like Excel, can be used. Since its introduction, ANP has been getting more widely used in decision making and numerous applications which have been published in literature. Jin and Soung (1998) used an integrated approach of ANP and goal programming for interdependent information system project selection.

### 3.1.1 Why ANP?

- The power of the ANP lies in its use of ratio scale to capture all kinds of interaction and to make accurate prediction, and even further to make better decisions.

- So far, it has proven itself to be a success when expert knowledge is used with it to predict sports outcome, economics turns, business, social and political decision outcomes.

### 3.1.2 Factors Influencing Supplier Selection

- Supplier selection is having two particular issues for discussion.
  - which criteria should be considered
  - what methods should be used.
Dickson (1966) has identified 23 criteria in the supplier selection process that had given a framework for the consideration of the factors. Further these criteria were expanded and some new criteria were added. Criteria were expanded into sub-criteria like the net price which can be subdivided into discounts, the fixed cost, design cost, supplier cost, inventory holding cost fixed ordering cost, freight charges etc.

3.2 ANP BASED SUPPLIER SELECTION PROCESS

The selection process has been modified to a five-step hybrid procedure, as follows:

Step 1. Identification of necessary criteria for vendor selection
Step 2. Recognition of the interdependence between criteria
Step 3. Calculation of relative impact value
Step 4. Evaluation of important criteria
Step 5. Result of ANP

3.2.1 Identification of Necessary Criteria for Supplier Selection

In this model, twelve potential important criteria given below are considered:

1. Quality
2. Quantity
3. Delivery time
4. Demand
5. Cost
6. Discount
7. Sales after service
8. Communication system
9. Technical Capability
10. Production facilities
11. Geographical location
12. Professionalism of Sales person
The above criteria are discussed in detail in the following section:

1. **Quality**

   It talks about the overall quality in the firm and the product. It assesses the firm’s quality standards the policies and procedures, their in-process quality management system and the quality control procedures.

   **i. Quality Management:** This sub-criterion evaluates completely the internal quality of the firm. It should be able to gauge, in entirety, how the vendor manages the quality function in his firm. This can be judged through the two factors: Quality planning and quality control.

   **a. Quality Planning:** The quality planning of the firm refers to the efforts directed towards preventing quality problems. It includes the quality policies and procedures along with the quality check points that are to be followed. The documentation about the quality practices followed in the firm, together with detailed operating procedures, should be available. Records are very important since it forms the basis of any action that can be taken.

   **b. Quality Control:** The vendor must have adequate methods to analyze the quality of the product, take necessary corrective action and plan for improvements in the process to get better adherence to quality. There should be adequate cause and effect analysis and statistical methods for the quality control process to be
successful. There should be a good method of segregating the non-confirming products.

ii. Product Quality: Quality guidelines are established, based on the requirements of the customer of the product. Product evaluation consists of evaluating conformance with these guidelines. This is the final and most important proof of performance. Demerit rating and reliability score can be used to judge the product quality.

iii. Quality Awards/Certificates: The certificates/awards received by the vendor at the national or international level by virtue of the quality standards achieved in his firm are given priority. This gives validity to the processes followed by him on a higher level.

Quality factors include:

- Compliance with purchase order. The vendor should comply with terms and conditions as stated in the purchase order. Does the vendor show an understanding of the customer firms expectations?

- Conformity to specifications. The product or service must conform to the specifications identified in the request for proposal and purchase order. Does the product perform as expected?

- Reliability. Is the rate of product failure within reasonable limits?

- Reliability of repairs. Is all repair and rework acceptable?
• Durability. Is the time until replacement necessarily reasonable?

• Support. Is quality support available from the vendor? Immediate response to and resolution of the problem is desirable.

• Warranty. The length and provisions of warranty protection offered should be reasonable. Are warranty problems resolved in a timely manner?

• State-of-the-art product/service. Does the vendor offer products and services that are consistent with the industry state-of-the-art? The vendor should consistently refresh product life by adding enhancements. It should also work with the buying firm in new product development

2. Quantity

Quantity is a kind of property which exists as magnitude or multitude. It is among the basic classes of things along with quality, substance, change, and relation. Quantity was first introduced as quantum, an entity having quantity. Being a fundamental term, quantity is used to refer to any type of quantititative properties or attributes of things. Some quantities are such by their inner nature (as number), while others are functioning as states (properties, dimensions, attributes) of things such as heavy and light, long and short, broad and narrow, small and great, or much and little.

Two basic divisions of quantity, magnitude and multitude, imply the principal distinction between continuity (continuum) and discontinuity.
Under the names of multitude come what is discontinuous and discrete and divisible into indivisibles, all cases of collective nouns: army, fleet, flock, government, company, party, people, chorus, crowd, mess, and number. Under the names of magnitude come what is continuous and unified and divisible into divisible, all cases of non-collective nouns: the universe, matter, mass, energy, liquid, material, animal, plant, tree.

Along with analyzing its nature and classification, the issues of quantity involve such closely related topics such as the relation of magnitudes and multitudes, dimensionality, equality, proportion, the measurements of quantities, the units of measurements, number and numbering systems, the types of numbers and their relations to each other as numerical ratios.

Thus quantity is a property that exists in a range of magnitudes or multitudes. Mass, time, distance, heat, and angular separation are among the familiar examples of quantititative properties. Two magnitudes of a continuous quantity stand in relation to one another as a ratio, which is a real number.

3. **Delivery Time**

The delivery criterion includes both the time factor as well as the quantity factor. It should be noted that adequate documentation regarding the material is brought at the time of delivery. This document involves details about the material such as quantity, quality, specifications, order number, etc., and care should be taken to regularly update it to have a complete report about the delivery performance of the vendor.

Delivery factors include the following:

- **Time:** Does the vendor deliver products and services on time; is the actual receipt date on or close to the promised date?
Does the promised date correspond to the vendor’s published lead times? Also, are requests for information, proposals, and quotes swiftly answered?

- **Quantity:** Does the vendor deliver the correct items or services in the contracted quantity?

- **Lead time:** Is the average time for delivery comparable to that of other vendors for similar products and services?

- **Packaging:** Packaging should be sturdy, suitable, properly marked, and undamaged. Pallets should be the proper size with no overhang.

- **Documentation:** Does the vendor furnish proper documents (packing slips, invoices, technical manual, etc.) with correct material codes and proper purchase order numbers?

- **Emergency delivery:** Does the vendor demonstrate extra effort to meet requirements when an emergency delivery is requested?

4. **Demand**

Demand is an economic model of price determination in a market. It concludes that in a competitive market, the unit price for a particular good will vary until it settles at a point where the quantity demanded by consumers (at current price) will equal the quantity supplied by producers (at current price), resulting in an economic equilibrium of price and quantity.

The four basic laws of supply and demand are if demand increases and supply remains unchanged then higher equilibrium price and quantity.
1. If demand decreases and supply remains the same then lower equilibrium price and quantity.

2. If supply increases and demand remains unchanged then lower equilibrium price and higher quantity.

3. If supply decreases and demand remains the same then higher price and lower quantity.

5. **Cost / Price**

This factor compares the vendors on the basis of the quoted price and induces competitiveness among them. Some form of cost reduction in case of a long-term association with the vendor, together with any sort of discounts or privileges that can be obtained, should be kept in mind.

Pricing factors include the following:

- Competitive pricing: The prices paid should be comparable to those of vendors providing similar product and services. Quote requests should compare favorably to other vendors.

- Price stability: Prices should be reasonably stable over time.

- Price accuracy: There should be a low number of variances from purchase-order prices on invoiced received.

- Advance notice of price changes: The vendor should provide adequate advance notice of price changes.

- Sensitive to costs: The vendor should demonstrate respect for the customer firm's bottom line and show an understanding of its needs. Possible cost savings could be suggested. The
vendor should also exhibit knowledge of the market and share this insight with the buying firm.

- Billing: Are vendor invoices accurate? The average length of time to receive credit memos should be reasonable. Estimates should not vary significantly from the final invoice. Effective vendor bills are timely and easy to read and understand.

6. Discount

Discounts and allowances are reductions to a basic price of goods or services.

The can occur anywhere in the distribution channel, modifying either the manufacturer's list price (determined by the manufacturer and often printed on the package), the retail price (set by the retailer and often attached to the product with a sticker), or the list price (which is quoted to a potential buyer, usually in written form).

There are many purposes for discounting, including; to increase short-term sales, to move out-of-date stock, to reward valuable customers, to encourage distribution channel members to perform a function, or to otherwise reward behaviors that benefit the discount issuer. Some discounts and allowances are forms of sales promotion.

7. Sales after service

The service factor has been measured on the basis of the importance of the service dimensions in the buying firms’ supplier selection. These include the supplier’s attitude to handling complaints and the ability and willingness to provide problem – solving aids and to share supplier’s logistic information. The service factor is especially important because the
maintenance and repair industry often run into the problem when the major components are needs to be replaced.

These are Service Factors to consider:

- Good vendor representatives have sincere desire to serve. Vendor representatives display courteous and professional approach, and handle complaints effectively. The vendor should also provide up-to-date catalogs, price information, and technical information. Does the vendor act as the buying firm’s advocate within the supplying firm?

- Inside sales. Inside sales should display knowledge of buying firms needs. It should also be helpful with customer inquiries involving order confirmation, shipping schedules, shipping discrepancies, and invoice errors.

- Technical support. Does the vendor provide technical support for maintenance, repair, and installation situations? Does it provide technical instructions, documentation, general information? Are support personnel courteous, professional, and knowledgeable? The vendor should provide training on the effective use of its products or services.

- Emergency support. Does the vendor provide emergency support for repair or replacement of a failed product.

- Problem resolution. The vendor should respond in a timely manner to resolve problems. An excellent vendor provides follow-up on status of problem correction.
Quality, price, and service are three factors, critical to the success of any export sales effort. Quality and price are addressed in earlier chapters. Service, which is addressed here, should be an integral part of any company's export strategy from the start. Properly handled, service can be a foundation for growth. Ignored or left to chance, it can cause an export effort to fail.

Service is the prompt delivery of the product. It is courteous sales personnel. It is a user or service manual modified to meet the customer's needs. It is ready access to a service facility. It is knowledgeable, cost-effective maintenance, repair, or replacement. Service is location. Service is dealer support.

Service varies by the product type, the quality of the product, the price of the product, and the distribution channel employed. For export products that require no service - such as food products, some consumer goods, and commercial disposables - the issue is resolved once distribution channels, quality criteria, and return policies have been identified.

On the other hand, the characteristics of consumer durables and some consumables demand that service be available. For such products, service is a feature expected by the consumer. In fact, foreign buyers of industrial goods typically place service at the forefront of the criteria they evaluate when making a purchase decision.

All foreign markets are sophisticated, and each has its own expectations of suppliers and vendors. U.S. manufacturers or distributors must therefore ensure that their service performance is comparable to that of the predominant competitors in the market. This level of performance is an important determinant in ensuring a reasonable competitive position, given the other factors of product quality, price, promotion, and delivery.
An exporting firm's strategy and market entry decision may dictate that it does not provide after-sale service. It may determine that its export objective is the single or multiple opportunistic entry into export markets. Although this approach may work in the short term, subsequent product offerings will be less successful as buyers recall the failure to provide expected levels of service. As a result, market development and sales expenditures may result in one-time sales.

8. Communication system

It determines and implements effective arrangements for communicating with customers in relation to:

- product information,
- enquiries, contracts or order handling, including amendments, and
- customer feedback, including customer complaints.

Purchasing information describes the product to be purchased, including where appropriate

- requirements for approval of product, procedures, processes and equipment,
- requirements for qualification of personnel, and
- quality management system requirements

9. Technical Capability

This factor takes into account whether the technology and facilities available in the firm are capable of doing the job as specified by the buyer’s organization.
i. Adequate Manufacturing Facilities/ Technology: The facilities should be available in sufficient numbers to be able to process the required quantity as specified in the order.

ii. Ability to Adapt to Changes: The facilities in the firm should be flexible enough to adapt to any future changes in design that may take place. The vendor, without much of a problem, should incorporate these changes.

iii. New Technology Assimilation: There should be a regular update of technology in the organization by virtue of new technology development or absorption, i.e., through Research and Development or Technology Transfer respectively.

10. Production facilities

Company should have the facilities for producing the components which are required by the customer. The facilities include manpower, machine power, production time etc.

A production planning and control system comprises two activities: planning/control of materials and planning/control of capacities. These two activities must be coordinated based on marketplace requirements. Capacity planning techniques are designed to estimate capacity requirements far enough into the future to fulfill market requirements. Capacity plans should be implemented carefully to avoid unpleasant surprises.

11. Geographical location

With the advances in logistics and information technology, business has transcended geographical boundaries. The globalization of the world economy has resulted in an increase in the number of firms that have shifted
their concentration on domestic sourcing to development of supplier bases around the world. The relaxation of trade barriers and the awareness of the relative strengths of the diverse geographical regions of the world have led to this increased interest in international sourcing. As information technology continues to introduce more advanced means for closer coordination of supply chains, we can anticipate further reduction in the importance of the geographic location of the vendor in the supplier selection decision problem.

12. Professionalism of Sales person

Sales person should have exposure in the area of marketing, sales and negotiating regarding the product quality with the customer. He should be properly trained for promoting new product introduced by the company. Also he should know the marketing strategies followed by the competitor.

3.2.2 Recognition of the Interdependence between Criteria

The factors involved in the vendor evaluation need to be identified with great care. These factors are chosen keeping in mind the organizational needs. For this, around 15 people, who are constantly in touch with vendors, were selected. They were given the complete picture about the objective of the study and specifically vendor evaluation. Initially, discussions were held with them about the main criteria that they considered during rating a supplier and each participant was asked to enlist the parameters they felt relevant in the rating process. These factors are discussed in detail and every aspect was noted about them, which required an approximate 30 - 45 minutes with each selected senior official. The criteria discussed were compiled into a single sample list of twelve major criteria. Attached along with the list was a complete explanation of the various criteria that were arrived. This was again subject to discussions with the same people and further suggestions were
incorporated. A consensus was finally reached and it was decided to incorporate twelve major criteria as shown in Figure 3.2.

![Figure 3.2 Interdependent Relationship between the Selected Criteria](image)

### 3.2.3 Calculation of Relative Impact Value

The following Tables 3.1 to 3.4 show the calculation degree of relative impact as the result of ANP. The ANP procedure is given below.

1. Assign preference values for criteria
2. Calculate reciprocal matrix for the criteria
3. Arrive column-wise total for the reciprocal matrix
4. Calculate degree of relative impact for evaluation of criteria

### 3.2.4 Evaluation of Important Criteria

The important criteria are selected based on the order of maximum value of relative impact as shown in Table 3.4.
### Table 3.1 Assign preference values for criteria

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Table 3.2 Calculate reciprocal matrix for the criteria

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Table 3.3  Arrive column-wise total for reciprocal matrix

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3.2.5 Result of ANP

The result of ANP is based on the values of relative impact of the criteria. The important criteria obtained as the results of ANP (Table 3.5).

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3.3 BRIEF SUMMARY

In this chapter, a detailed discussion has been made on ANP, factors influencing supplier selection, ANP based supplier selection process, identification of necessary criteria. The important criteria obtained as the result of ANP (relative impact) are quality, quantity, delivery time, demand and cost.