Selection of Vendor Attributes Using Artificial Neural Network

A Major Project thesis

Submitted in partial fulfillment

For the requirement of the degree of

Masters of Engineering

In

Production and Industrial Engineering

By

Swapan Kumar

(02/pro/2005)

Under the guidance of

PROF. S. K. GARG

DEPARTMENT OF MECHANICAL ENGINEERING
DELHI COLLEGE OF ENGINEERING
DELHI UNIVERSITY, DELHI-110042

June, 2007

Candidate's Declaration

I hereby certify that the work which is being presented in the dissertation entitled "Selection of vendor attributes using Artificial neural networking ", in partial fulfillment of the requirements for the award of the degree of Master of Engineering in Production and Industrial Engineering, submitted in the Department of Mechanical Engineering, Delhi College of Engineering, Delhi is an authentic record of my own work carried out for a period of one year under the supervision of Dr. S. K. Garg, Professor of Mechanical Engineering Department, Delhi College of Engineering, Delhi.

I have not submitted the matter embodied in this dissertation for the award of any other degree.

Swapan Kumar

This is to certify that the above statement made by the candidate is true to the best of my knowledge.

Dr. S. K. Garg

Professor
Department of Mechanical & Production Engineering
Delhi College of Engineering,
Delhi-110042 (India)

Acknowledgment

Knowledge comes from Acknowledgement. The more one acknowledge people, books, institute, the more knowledge the one get. Here, I would like to acknowledge those people and institute who have given me the knowledge and light of guidance which has helped me to wade through the darkness. Here, I express my heartily and sincere gratitude and indebtedness to Dr. S. K. Garg, Professor of Mechanical Engineering Department, Delhi College of Engineering, Delhi for his valuable guidance and wholehearted cooperation. He has a special place in my heart for many reasons but to be limited, he is the one who inspires me to move ahead in life with persistence and endurance. I would like to acknowledge Delhi College of Engineering and all those companies who gave me resources and people to support me while pursuing my post graduation and working upon this project.

My heartily thanks to all of my Professors for their expertise and all rounded personality they have imparted me.

I would like to acknowledge all my friends especially Vipin Kumar Sharma for their support, sincerity and cooperation, who flourish my stay here.

My special thanks go to my parents who have given me the strength, love and care to carry out this course successfully.

Swapan Kumar

Contents

Chapter 3: METHODOLOGY

Chapter 4: SELECTION OF VENDOR ATTRIBUTES USING ANN

Chapter 5: CONCLUSION AND FUTURE SCOPE

List of Figures

List of Tables

Executive Summary

Vendor selection is a discipline in which extensive research has been carried out and numerous methodologies churned out. The vendor selection problem deals with issues related to the selection of right vendors and their quota allocations. In designing a supply chain, a decision maker must consider decisions regarding the selection of the right vendors. The choice of the right vendor is a crucial decision with wide ranging implications in a supply chain. Vendors play an important role in achieving the objectives of the supply management. Vendors enhance customer satisfaction in a value chain. Hence, strategic partnership with better performing vendors should be integrated within the supply chain for improving the performance of an organization.

There are numerous criterions and approaches present in the literature for the selection of vendor but the vendor selection process has undergone significant changes during the past twenty years. These include increased quality guidelines, improved computer communications, and increased technical capabilities. So, in the current scenario an approach is required which can take care of these fast changes in the selection process and hence a number of intelligence approaches are used to solve this problem. Artificial Neural Networking is one of the intelligent approaches, which is used in this project.

This project report provides an application based on artificial neural networking to select the attributes of a vendor and introduces a consolidated, systematic approach to the redesign the process of vendor selection.

Key words: - Artificial Neural Networking, Mat lab, Neurons, Application, Transfer function, Learning of network, Feed-forward network, Network layers, Vendor and Buyer attributes.

Chapter 1
INTRODUCTION

1.1 Background

During the last decade, the business environments all over the globe have undergone and experience significant change. In particular, the purchasing environment has become one of the most crucial element in establishing the value- added contents for products and services and hence has become a vital determinant to ensure the profitability and survival of business organizations. Materials represent a substantial part of the value of product. The key objective of the purchasing department is to purchase the right quality of material in the right quantity from the right source at the right time and at a reasonable price.

Supplier management is one of the main fields in industrial engineering where much research efforts were spent and numerous approaches were developed and under this area, supplier selection and development are the key factors. Increasing competition, shorter product life cycles, and heightened customer expectations have led many companies to a more comprehensive focus on supplier selection and development versus the traditional physical logistic emphasis.

A typical supply chain consists of different activities among those the most important of all is the purchasing at the manufacturer end. Purchase items and services accounts for 60% to 70% of the cost of good sold consequently, buying from outside allows the firm to focus on the activities that present its core competencies. Thus, a company can create a competitive advantage while reducing cost.

Supplier selection and development came in picture in early fifties of nineteenth century. But In recent years, the relationship between buyers and suppliers has received considerable attention. With the globalization of markets combined with a restructuring of many firms, with a focus towards costs, quality, delivery, flexibility and technology, a new role for procurement has emerged. Traditionally, purchasing was considered as a clerical function, where the relationship between suppliers and buyers tended to be adversarial. A number of factors are identified which are important in vendor selection and a number of approaches are developed to select the most suitable vendor as per the requirement of the buyer, in the current scenario intelligence approaches like

- Case based reasoning
- Expert systems
- Genetic Algorithm
- Fuzzy logic
- Neural network etc

are highly used to solve the problem of vendor selection.

1.2 Objective

It is fairly easy to abstract a list of at least 50 distinct factors that are meaningful in the consideration during the vendor selection process *Dickson (1966)*. As well as different methods like

(i) Linear weighting methods,
(ii) Mathematical programming models,
(iii) Statistical methods.

Linear weighting methods are the most common for VSP. *Wind and Robinson (1968), Mazurak et al. (1985), Cooper (1977)* and many others endorsed this using a weighted linear method of multiple criteria for vendor selection. *Timmerman (1986) and Gregory (1986)* linked this approach to a matrix representation of data and *Narsimhan (1983)* employed the analytical hierarchical process to generate weights for such models. Mathematical programming approaches have been extensively used for the VSP. These include linear programming, mixed integer programming and goal programming etc. *Anthony and Buffa (1977)* formulated VSP as a LP problem with the objective to minimize total purchasing and storage costs.

But due to the fact that the evaluation always involves conflicting performance criteria of vendors, the technique of ARTIFICIAL INTELLIGENT SYSTEMS are coherently derived to manage the problem. In this project, my objective is to develop an artificial intelligent system that can make intelligent decision based on the past experiences. I used neural network for the development of this system.

1.3 Scope of project

Vendor selection or evaluation is a common problem for acquiring the necessary materials to support the outputs of organizations. The problem is to find and to evaluate periodically the best or most suitable vendor(s) for the organizations based on various vendors' capabilities. This problem becomes more complicated when the purchase is complex, high-dollar value, and perhaps critical *Dobler and Burt (1996)*. Also, a process of formal vendor evaluation and ranking is necessary. We have different quantitative approaches for vendor evaluation, which covers the works of problem definition, formulation of criteria, qualification, and choice *Shih, Wang and Lee, (2004). W*hich can roughly be divided into four categories: multi-attribute decision making (or a general view of linear weighting models), multi-objective optimization (or a general view of mathematical/linear programming models), statistics/probabilistic approaches, intelligent approaches, and others.

Category	Approach	Proposed by.
MADM model	AHP Conjoint analysis Linear weighting method Outranking method	Nydick and Hill (1992) Mummalaneni et. al. (1996) Dobler and Burt (1996) De Boer et. al. (1998)

MODM model	e- constraint method	Weber and Current (1993)
	DEA	Weber (1996)
	Goal Programming	Buffa and Jackson (1983)
Statistical/Probabilistic approaches	Categorical method	Zenz (1981)
	Cluster analysis	Hinkle et. al. (1969)
	Uncertainty analysis	Soukoup (1987)
Intelligence approaches	Case based reasoning	Cook (1997)
	Expert systems	Vokurka et. al. (1996)
	Genetic Algorithm	Ding et. al. (2003)
	Fuzzy logic	Kumar et. al.(2005)
	Neural network	Wei et. al. (1997)
Others	Activity based costing	Roodhooft and Konings (1996)
	Interpretive structure modeling	Mandal and Deshmukh (1994)

Table 1.1 Various categories of vendor selection approaches

The first category concentrates on selection activities, which adopt a limited and countable number of predetermined alternatives through multiple attributes or criteria. The alternatives associate with them the level of achievement of the attributes. Though it may still be in doubt whether they are quantifiable or not, those attributes will act as a platform upon which the final choice is to be made *Hwang and Yoon (1981).* Most approaches utilized, such as AHP, conjoint analysis, the linear weighting (or scoring) method and the outranking method can be classified into this category.

The second category involves the design for the best or required alternative by taking into consideration the various interactions within the design constraints that best satisfy the decision maker by way of attaining some acceptable levels of a set of some quantifiable objectives. Its alternatives have been implicitly expressed in the feasible zone of a constraint set, so that the most satisfactory

objectives can be obtained *Hwang and Masud (1979).* Techniques such as the "-constraint method, data envelopment analysis (DEA), and goal programming contribute to this category.
The third category focuses on the evaluation which relies on a large number of tests or surveys or deals with the stochastic uncertainty related to the vendor choice. The categorical method, cluster analysis and uncertainty analysis all fall into this category.

The fourth and most recent category explores some newly developed intelligent techniques, such as case-based reasoning, expert systems, genetic algorithms, and neural networks, to process the activities of vendor selection.
So in this project I work out a decision support intelligent system using neural networking which will learn from the previous inputs and results and on the basis of that leaning it will make intelligent decisions. As in all other approaches of vendor selection we need to provide input and the computation approach which has to be applied on the input in order to get the output but in this model we are not required to provide the computational method which has to applied on the output rather we need to provide the input conditions as well as output conditions and based on the input and output conditions it will itself develop its intelligence (very much similar to human) and when we will provide the input to it based on the experience it has, it will make the decisions.

1.4 Methodology

In this project, an extensive literature review related to vendor attributes and vendor selection technique has been done and based on the literature review it has been found out that the intelligent techniques are highly useful to solve the problem of vendor attributes selection. So, an intelligent technique”neural network “has been selected to work out this problem. First of all a questionnaire (sample attached) has been prepared which covers the various attributes of buyer and supplier related to the vendor selection and then, this questionnaire has been distributed to various companies like.

- Hero Honda motors
- Sharda motors
- Maruti udhog limited
- Whirlpool
- Denso Haryana Pvt. Limited.
- LG Electronics India Pvt Ltd
- Honda motor cycle and scooter India limited
- Coca Cola India limited
- Hyundai motors India limited
- MICO India limited
- BPL Display Device limited
- Hyundai motors India limited
- Minda horn divison
- GEMI motors India Pvt. Limited etc.

And get the questionnaire filled. Consequently an application has been developed using neural networking which is capable to learn the buyer's factors as input and vendor attributes as output then the data which was collected from various companies is used, to learn software so that the software would develop its intelligence. Then a sample has been taken and results of actual output to the software output are compared.

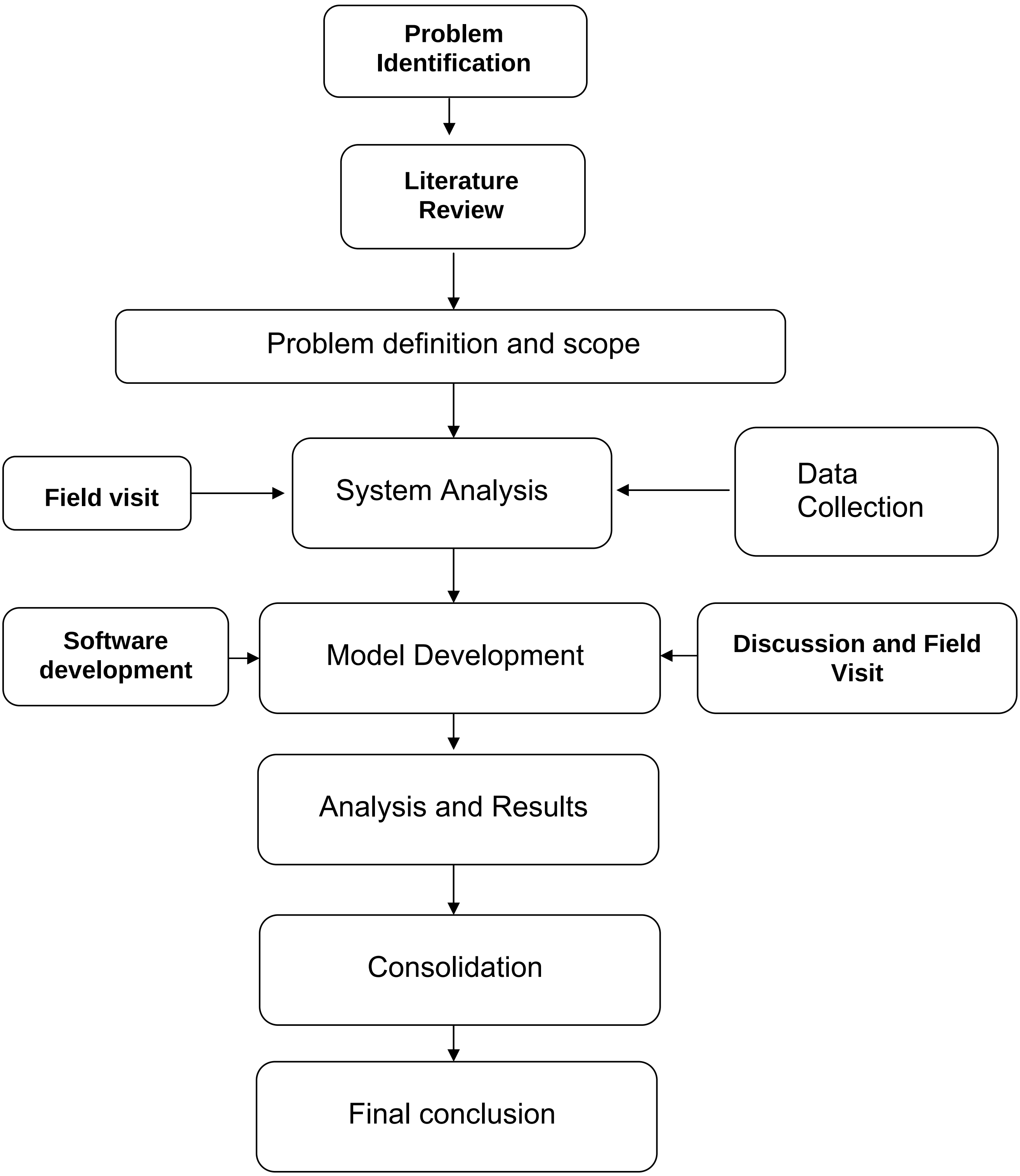


Fig 1.1 Methodology of project

Chapter 2
LITERATURE SURVEY

2.1 Introdction

OUTSOURCING: - Purchase items and services accounts for 60% to 70% of the cost of good sold *Burton (1988)*. Outsourcing *Ogburn (1994)* is a term used to describe when a firm purchase materials, parts, assemblies and other services to be used in its main product, which is the identity of the company. Buying from outside allows the firm to focus on the activities that present its core competencies. Thus, a company can create a competitive advantage while reducing cost. The outside agencies that provide these materials, subassemblies and services are known as *Vendors*.

Advantage of outsourcing

1) Cost reduction
2) Focus on core competencies
3) Improved efficiencies
4) Minimization of inventory, material handling and non value added costs

The above mentioned facts help us establish that in today's competitive industrial scenario, a company can survive and grow when it cuts its non value added costs and concentrate on its core competencies. This further convinces us about the indispensability of outsourcing.

However, outsourcing skeptics claim that an outsider cannot give the same concentration and focus as the in house team. It therefore because imperative to do thorough vendor scrutiny before entrusting critical technical roadmaps and confidential information on him. Understanding the emphasis of a vendors business, or what it is that drives him to meet specific needs. The vendor selection team should be a cross functional one comprising of senior management, legal staff with contract expertise, technical staff, end users and financial staff. *Honess and Chance (1996).*

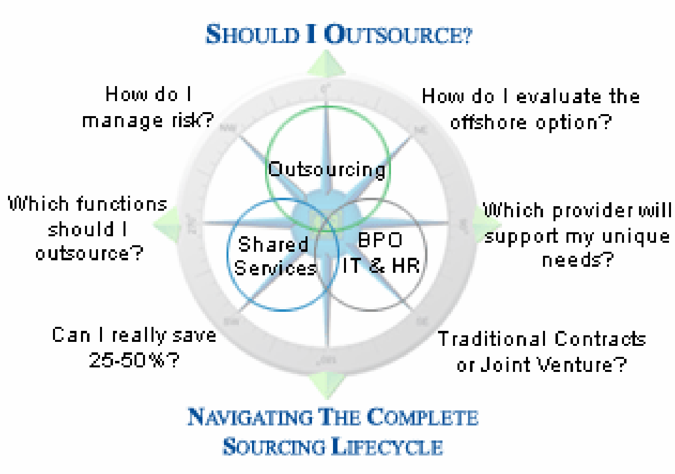


Fig 2.1 Outsourcing decisions

Risk of out sourcing

1) Loss of control
2) Exposure to suppliers risk
3) Possibility of being tied to obsolete technology
4) Supply constraints
5) Attention required by top management

Experiences have shown that when good suppliers are involved early in the buyers design process, they can make a direct contribution to the firm success. Such suppliers can assist in the product development, value analysis by applying their expertise in the field of; material specifications, tolerances, standardization, order sizes, transportation etc.

A single vendor is justified when,

1) When better pricing due to large volume
2) Reduced inventory
3) Improved commitment
4) Low freight due to higher volumes

Multiple vendors are justified when,

1) To protect during times of shortages, strikes etc.

2) To maintain competition and provide a back up source
3) To meet sudden high volume requirement sometimes.

Immaterial of whichever of the above two practices is adopted it has now become an establishing fact that “Selection and management of right vendor is the key to success of any company in today’s cut throat competition”.

2.2 Vendor selection criterions

Because of the emphasis on outsourcing, strategic partnering, strategic alliances, and relationship marketing, many organizations purchase not only raw materials and basic supplies but also complex fabricated components with very high value-added content and services. Vendor selection or supplier evaluation continues to be a key element in the industrial buying process and appears to be one of the major activities of the professional industrial, *Patton (1997) and Michaels, Kumar and Samu (1995).*
Selecting an appropriate vendor is often a non-trivial task, and is complicated by the fact that various criteria must be considered in the decision making process *Weber, Current and Benton (1991).* A list of twenty factors has been identified *(Dickson (1966)* these factors are as follows.

Table 2.1 List of vendor attributes

DIFFERENT VENDOR SELECTION CRITERIA		
S.No.	**FACTOR**	**REFERENCES**
1	**Quality**	Ansari and Modarress (1986), Bender, Brown, Isaac and Shapiro (1985), Benton and Krajewski (1990), Bernard (1989), Buffa and Jackson (1983), Burton (1988), Cardozo and Cagley (1971), Chapman (1989), Chapman and Carter (1990), Croell (1980), Dempsey (1978), Frazier, Spekman and O'Neal (1988), Gregory (1986), Hahn, Kim and Kim (1986), Hahn, Pinto and Bragg (1983), Hakansson and Wootz (1975), Hinkle, Robinson

		and Green (1969), Jacobson and Aaker (1987), Jackson (1983), Kraljic (1983), Lamberson, Diederich and Wuori (1976), Manoochehri (1984), Mazurak, Rao and Scotton (1985), McFillen, Reck and Benton (1983), Monczka, Giunipero and Reck (1981), Moore and Fearon (1973), Sharma, Benton and Srivastave (1989),
2	**Delivery**	Ansari and Modarress (1986), Ansari and Modarress (1988), Anthony and Buffa (1977), Banerjee (1986), Bragg and Hahn (1982), Browning, Zabriskie and Huellmantel (1983), Cooper (1977), Croell (1980), Dempsey (1978), Frazier, Spekman and O'Neal (1988), Sharma, Benton and Srivastave (1989), Sheth (1973), Shore (1981), Soukup (1987), Timmerman (1986)
3	**Performance history**	Buffa and Jackson (1983), Dempsey (1978), Lamberson, Diederich and Wuori (1976), Monczka, Giunipero and Reck (1981), Timmerman (1986), Wind and Robinson (1968)
4	**Warranties and claim policies**	Narasimhan (1983),
5	**Production facilities and capacity**	Bender, Brown, Isaac and Shapiro (1985), Bragg and Hahn (1982), Browning, Zabriskie and Huellmantel (1983), Burton (1988), Chapman (1989), Dempsey (1978), Gaballa (1974), Gregory (1986), Hahn, Kim and Kim (1986), Hahn, Pinto and Bragg (1983), Ho and Carter (1988), Kraljic (1983), Narasimhan and Stoynoff (1986), Turner (1988), Wieters (1976)

6	**Price**	Ansari and Modarress (1986), Anthony and Buffa (1977), Banerjee (1986), Bender, Brown, Isaac and Shapiro (1985), Benton (1983), Benton (1985), Benton and Whybark (1982), Browning, Zabriskie and Huellmantel (1983), Buffa and Jackson (1983), Burton (1988), Cardozo and Cagley (1971), Chakravarty and Martin (1988), Dada and Srikanth (1987), Dempsey (1978), Frazier, Spekman and O'Neal (1988), Gaballa (1974), Goyal (1987), Gregory (1986), Hahn, Kim and Kim (1986), Hahn, Pinto and Bragg (1983), Hakansson and Wootz (1975), Hinkle, Robinson and Green (1969), Hwang, Moon and Shinn (1990), Jordan (1987), Kingsman (1986), LaForge (1985), Lamm and Vose (1988), Lee and Rosenblatt (1986), Levy and Cron (1985), Markowski and Markowski (1988), Mazurak, Rao and Scotton (1985), McFillen, Reck and Benton (1983), Monahan (1984), Narasimhan and Stoynoff (1986), Pan (1989), Ronen and Trietsch (1988), Rubin, Dilts and Barton (1983), Sheth (1973), Shore (1981), Soukup (1987), Turner (1988), Wagner, Ettenson anParrish(1989),
7	**Technical capability**	Browning, Zabriskie and Huellmantel (1983), Burton (1988), Dempsey (1978), Frazier, Spekman and O'Neal (1988), Gregory (1986), Hahn, Kim and Kim (1986), Hinkle, Robinson and Green (1969), Kraljic (1983), Mazurak, Rao and Scotton (1985), Newman (1988), Sheth (1973), Soukup (1987)
8	**Financial position**	Dempsey (1978), Lamberson, Diederich and Wuori (1976), Monczka, Giunipero and Reck (1981), Roberts (1978), Soukup (1987), Wieters (1976)
9	**Procedural compliance**	Dempsey (1978)

10	**Communication system**	Dempsey (1978), Wind and Robinson (1968)
11	**Reputation and position in industry**	Cardozo and Cagley (1971), Monczka, Giunipero and Reck (1981), Sheth (1973), Wagner, Ettenson and Parrish (1989), Wieters (1976), Wind and Robinson (1968)
12	**Desire for Business**	Soukup (1987)
13	**Management and organization**	Bernard (1989), Burton (1988), Edwards (1967), Frazier, Spekman and O'Neal (1988), Lamberson, Diederich and Wuori (1976), Wieters (1976)
14	**Operating control**	Burton (1988), Dempsey (1978), Monczka, Giunipero and Reck (1981), Wieters (1976)
15	**Repair service**	Benton and Krajewski (1990), Bernard (1989), McFillen, Reck and Benton (1983), Sheth (1973), Wagner, Ettenson and Parrish (1989), Wieters (1976)
16	**Attitude**	Ansari and Modarress (1986), Ansari and Modarress (1988), Dempsey (1978), Jackson (1983), Manoochehri (1984)
17	**Impression**	McGinnis and Hollon (1978), Sheth (1973)
18	**Packaging ability**	Ansari and Modarress (1988), Burton (1988), Newman (1988)
19	**Labour relations record**	Monczka, Giunipero and Reck (1981)
20	**Geographical location**	Ansari and Modarress (1986), Burton (1988), Cardozo and Cagley (1971), Gregory (1986), Hahn, Kim and Kim (1986), Jackson (1983), Manoochehri (1984), Soukup (1987), Wagner, Ettenson and Parrish (1989), Wieters (1976), Wind and Robinson (1968)
21	**Amount of past business**	
22	**Training aids**	Burton (1988), Dempsey (1978)
23	**Reciprocal arrangements**	Sheth (1973), Wind and Robinson (1968)

These various research works have been reviewed in order to understand the significance of each parameter and how the importance of each parameter is changing day by day with the changing environment.

In the late 70's net price, delivery and quality were given the prime importance; production facility and technical capability were categorized as having considerable importance while geographic location was considered as only average importance.

In 80's net price, delivery and quality have received the greatest amount of attention while production facilities and capacity, geographical location, financial position and management and organization generated an intermediate amount of attention and warranties and claim policies, communication system, impression, labor relations record, amount of past business and reciprocal agreements have received little amount of attention.

But as we know that, strategic management decisions may affect the criteria used in making subsequent operational decisions. A review of JIT criteria for vendor selection appears appropriate in light of the recent movement of many firms. In the JIT environment quality and delivery are still the most important parameters but some new factors have also being recognized like production facilities and capabilities, net price is handled as the component of "total vendor cost " rather than as a separate component. Geographical location is another important criterion for vendors in JIT systems. This is not surprising given the emphasis on local suppliers in JIT systems. This is in marked contrast to the Dickson report where geographical location ranked twentieth in importance. Other criteria that were mentioned for consideration in the JIT vendor selection process are technical capability, attitude, management and organization, operational controls, service and packaging.

2.3 Quantitative approaches to vendor selection

These are the quantitative approaches to vendor selection, which are described in the various articles. These approaches may be grouped into four general categories:

(1) Linear weighting models,

- a) Linear weighting method
- b) Decision matrix approach
- c) Conjoint analysis
- d) Cost ratio plan

(2) Mathematical programming models

- a) Linear programming
- b) Mixed integer programming
- c) Goal programming

(3) Statistical/probabilistic approaches.

- a) Categorical method
- b) Cluster analysis
- c) Uncertainty analysis

(4) Intelligence approaches

- a) Case based reasoning
- b) Expert systems
- c) Genetic Algorithm
- d) Fuzzy logic
- e) Neural network

2.3.1 Linear weighting models

2.3.1.1 LINEAR WEIGHTED METHOD: Each vendor is scored on various factors like quality, quantity, price, service etc. these factors are then weighted and a composite rating is then calculated for each vendor.

Quality Rating $R_Q = \dfrac{Q_1+Q_2X_1+Q_3X_2}{Q}$

Where Q= Quality supplied,

Q_1= Quality accepted,

Q_2= Quality accepted with concession,

Q_3= Quality accepted with rectification,

Q_4= Quality rejected.

$Q = Q_1+Q_2+Q_3+Q_4$

X_1 and X_2 are the weight age factors each less than one

Delivery Rating $R_D = \frac{\text{Promised delivery time (days) X 100}}{\text{Actual delivery time (day)}}$

Quantity Rating

$$R_{QTY} = \frac{\text{Quantity supplied with in stipulated delivery time X 100}}{\text{Quantity promised}}$$

Service Rating:

a) Readiness and co operative ness to help in emergencies A_1

b) Readiness to replace rejected material A_2

c) Providing supportive documents in time A_3

d) Promptness in reply A_4

e) Acceptance of terms without much of complaints A_5

Where, $A_1+A_2+A_3+A_4+A_5 = R_S$

Composite vendor performance rating,

$$VPR = F_1R_Q + F_2R_P + F_3R_D + F_4R_{QTY} + F_5R_S$$

Where, $F_1+F_2+F_3+F_4+F_5=1$

Values of $X_1, X_2, F_1, F_2, F_3, F_4, F_5, A_1, A_2, A_3, A_4$ & A_5 to be fixed as suited to the organization.

2.3.1.2 DECISION MATRIX APPROACH TO VENDOR SELECTION **:**In this method the vendor are evaluated by considering certain factors like quality, price, delivery and quantity etc. all these important factors are given appropriate weight and each alternative is evaluated in terms of these factors. This approach is also known as multi factors evaluation process (MFEP)

In this process, we start by listing the factor and their relative importance on a scale from 0 to 1. For example, a company gives following weight to the desired factors.

Factors	weight
Quality	0.4
Price	0.4
Delivery	0.2

Let there be three vendors to be evaluated by this method and for all these three vendors say A, B & C the buyer company evaluates or rates the various factors on a scale of 0 to1 as shown below.

Factors		Vendor A	Vendor B	Vendor C
Quality		0.7	0.8	0.9
Price		0.9	0.8	0.7
Delivery		0.6	0.7	0.9

Table 2.2 Weight of various factors

For final evaluation, the various factors weights decided by the company are multiplied by the evaluated rates of different vendors. This will give us the weighted evaluation of each vendor. For each vendor, these weighted evaluations for different factors are added and vendor, whose total weighted evaluation is the highest, is selected as shown below.

Factor Name	Weighted Evaluation for vendor A	Weighted Evaluation for vendor B	Weighted Evaluation for vendor C
Quality	0.4*0.7 = 0.28	0.4*0.8 = 0.32	0.4*0.9 = 0.36
Price	0.4*0.9 = 0.36	0.4*0.8 = 0.32	0.4*0.7 = 0.28
Delivery	0.2*0.6 = 0.12	0.2*0.7 = 0.14	0.2*0.9 = 0.18
Total	0.76	0.78	0.82

Table 2.3 Decision matrix

The vendor C has received the highest total weighted evaluation. therefore the company would go with vendor C.

2.3.1.3 COST RATION PLAN: it compare vendors on the rupee cost for a specific purchase. Total cost includes quality cost and service cost. The final rating is in rupees of net value cost. The net value cost is the product of the adjusted unit price and the no. of units. The adjusted unit price incorporates three cost ratios as following,

1) The quality cost ratio reflects the relative cost of quality.
2) The delivery cost ratio reflects the relative cost of placing and receiving an order
3) The service cost ratio reflects the technical, managerial and field service competence of the vendor.

2.3.2 Mathematical programming models

2.3.2.1 LINEAR PROGRAMMING Garey and Johnson (1979):- Problems involve the optimization of a linear objective function, subject to linear equality and inequality constraints.

In vendor selection, we can represent the objective as the best vendor based on selected factors and constraints can be represented as the factors itself, then problems that can be expressed in standard form:

Maximize C^tX

Subject to $Ax<B$

Where, $x>=0$

x represents the vector of variables, while c and b are vectors of coefficients and A is a matrix of coefficients. The expression to be maximized or minimized is called the objective function (C^tX is this case). The equations $Ax \leq b$ are the constraints which specify a boundary in which the objective function is to be optimized.

Linear programming can also be utilized for modeling diverse types of problems in planning, routing, scheduling, assignment, and design also.

2.3.2.2 MIXED INTEGER PROGRAMMING APPROACH (Kasilingam and Lee, 1996): - As we have seen that in all the above methods generally take care of following factors:

1) Cost/ price
2) Quality
3) Delivery

But here are certain more factors which has to be taken care in order to rate a vendor like,

1) Stochastic nature of demand
2) Cost of transportation
3) Cost of receiving poor quality parts
4) Lead time requirement for the parts.

Mixed integer programming approach can take care of all these factors.
In this approach simplex method is used in order to optimize the cost, first calculation of the total cost due to all these factors is done and than defining the constraints i.e.

Decision Variables:

Xij = Quantity of part i to be ordered from vendor j

Y_{ij} = 1, if vendor j is selected for supplying part i
= 0, otherwise

Parameters

C_{ij} = Unit cost of purchasing plus transportation for part i from vendor j

d_{ij} = Unit variable cost due to receiving poor quality parts of type i from vendor j

D_i = Demand for part type i. D_i is assumed to be normally distributed with Parameters (μ_i,σ_i).

e_{ij} = Fixed cost due to receiving poor quality parts of type i from vendor j

f_{ij} = Fixed cost associated with establishing vendor j for part i

L_i = Maximum allowable lead time for part type i

L_{ij} = Lead time for receiving part type i from vendor j

P_i = Maximum number of vendors to be employed for part type i

P_{ij} = percentage of good parts of type i supplied by vendor j

q_{ij} = percentage of defective parts of type i supplied by vendor j (= 1- p_{ij})

S_{ij} = Availability of part type i from vendor j

Then, the vendor selection problem is formulated as the following chance-constrained integer programming model.

The objective here is to minimize the sum of
Purchasing and transportation costs,
Fixed costs for establishing vendors, and the
Fixed and variable costs due to receiving poor quality parts

This is represented as given in Equation (1).

$$\text{Minimize } Z = \sum_i \sum_j X_{ij} C_{ij} + \sum_i \sum_j Y_{ij} f_{ij} + \sum_i \sum_{j,\ q_{ij}>0} X_{ij} q_{ij} d_{ij} + \sum_i \sum_j Y_{ij} e_{ij} \qquad \text{Equation (1)}$$

The first part in Equation (1) represents the total costs of purchasing and transportation for all part types from all vendors.

The four important constraints that need to be modeled are related to the availability of parts from vendors, the demand for part types, the maximum number of vendors to be employed, and the maximum allowable lead times.

The availability of part types from various vendors is modeled as in Equation (2).

The maximum number of vendors to be employed for each part type is represented by Equation (3).

$X_{ij} \le S_{ij}$ for all i and j Equation (2)

$\sum_{j} Y_{ij} \le P_i$ for all i Equation (3)

Demand for part types is modeled as a chance constraint. The assumption here is that the management is interested in restricting the probability of total quantity received from all vendors for part type i exceeding the demand for part type i. This probability may be set as the same value (α) for all part types, or set differently for each part type (α_i), presumably, higher for critical part types. Hence, we have,

$P[\sum_{j} X_{ij} * p_{ij} \ge D_i] \le \alpha_i$ for all i Equation (4)

The constraint on maximum allowable lead time for various part types is represented by Equation (5). Equation (5) will help to reduce the number of decision variables and will not be explicitly included while solving the formulation. For instance, if the lead time for part type 1 from vendor 3 is greater than the maximum allowable lead time, then Y_{13} and X_{13} will be dropped from the formulation.

$L_{ij} Y_{ij} \le L_i$ for all i and j Equation (5)

Three other constraints are needed to ensure model consistency, and to impose non-negativity and integrality restrictions on the decision variables. The following constraints ensure model consistency, i.e., a vendor is established before orders are placed. This is represented by Equation (6), where M is a large positive integer.

Xij <= M Yij for all i and j Equation (6)

The non-negativity and integrality restrictions are represented by equation (7) and equation (8).

Xij >= 0 and integer for all i and j Equation (7)
Yij belongs to {0,1} for all i and j Equation (8)

Now, these equations can be used to incorporate all the parameters and identifying the best vendor which can fulfill the need of an organization in most effective and efficient way.

2.3.2.3 GOAL PROGRAMMING Charnes, Cooper and Ferguson,(1955) is a branch of multiple objective programming, which in turn is a branch of multi-criteria decision analysis (MCDA), also known as multiple-criteria decision making (MCDM). It can be thought of as an extension or generalization of linear programming to handle multiple, normally conflicting objective measures. Each of these measures is given a goal or target value to be achieved. Unwanted deviations from this set of target values are then minimized in an achievement function. This can be a vector or a weighted sum dependent on the goal programming variant used. As satisfaction of the target is deemed to satisfy the decision maker(s), an underlying satisfying philosophy is assumed.

2.3.3 Statistical/probabilistic approaches

2.3.3.1 CATEGORICAL PLAN**:** This is a non qualitative system in which the buyer holds a monthly meeting to discuss the vendor performance against certain factors like delivery time, price quality, quantity etc. and evaluate/rate them on qualitative scale in the form of good average bad etc or on a scale of 1 to 5 as per the format enclosed.

2.3.3.2 CLUSTER ANALYSIS (Hinkle et. al., 1969) is a class of statistical techniques that sorts through the raw data and groups them into clusters. A cluster is a group of relatively homogeneous cases or observations. Objects in a cluster are similar to each other. They are also dissimilar to objects outside the cluster, particularly objects in other clusters.

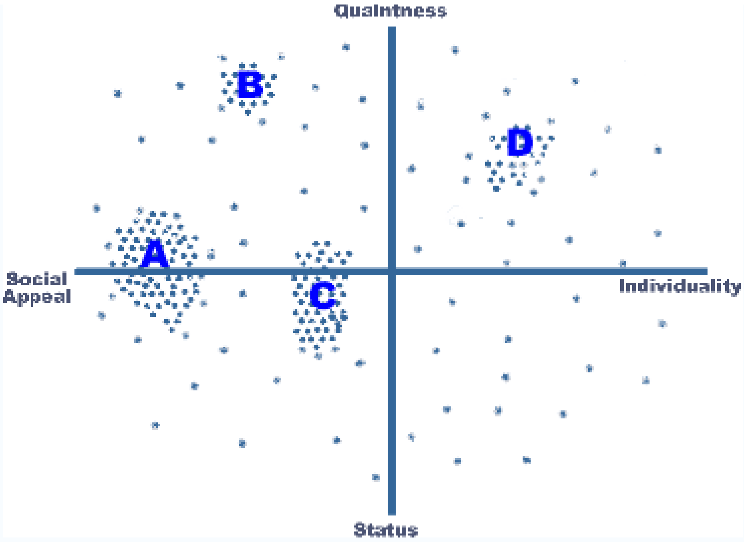


Fig 2.2 Illustration of clusters

Cluster analysis, like factor analysis and multi dimensional scaling, is an interdependence technique: it makes no distinction between dependent and independent variables. The entire set of interdependent relationships is examined. It is similar to multi dimensional scaling in that both examine inter-object similarity by examining the complete set of interdependent relationships. The difference is that multi dimensional scaling identifies underlying dimensions, while cluster analysis identifies clusters. Cluster analysis is the obverse of factor analysis. Whereas factor analysis reduces the number of variables by grouping them into a smaller set of factors, cluster analysis reduces the number of observations or cases by grouping them into a smaller set of clusters.

2.3.4 Intelligence approaches

2.3.4.1 CASE-BASED REASONING Cook (1997), broadly construed, is the process of solving new problems based on the solutions of similar past problems.

Various steps in case based reasoning are.

1. Retrieve: Given a target problem, retrieve cases from memory those are relevant to solving it. A case consists of a problem, its solution, and, typically, annotations about how the solution was derived.
2. Reuse: Map the solution from the previous case to the target problem. This may involve adapting the solution as needed to fit the new situation.
3. Revise: Having mapped the previous solution to the target situation, test the new solution in the real world (or a simulation) and, if necessary, revise.
4. Retain: After the solution has been successfully adapted to the target problem, store the resulting experience as a new case in memory.

2.3.4.2 FUZZY LOGIC Klir (1997), is derived from fuzzy set theory dealing with reasoning that is approximate rather than precisely deduced from classical predicate logic. It can be thought of as the application side of fuzzy set theory dealing with well thought out real world expert values for a complex problem. A fuzzy concept is a concept of which the content or boundaries of application vary according to context or conditions. Usually this means the concept is vague, lacking a fixed, precise meaning, without being meaningless altogether. It does have a meaning, or multiple meanings, which however can become clearer only through further elaboration and specification.

Fuzzy Logic incorporates a simple, rule-based IF X AND Y THEN Z approach to a solving control problem rather than attempting to model a system mathematically. The fuzzy logic model is empirically-based, relying on an operator's experience rather than their technical understanding of the system. fuzzy logic is capable of mimicking this type of behavior but at very high rate. fuzzy logic requires some numerical parameters in order to operate such as what is considered significant error and significant rate-of-change-of-error, but exact values of these numbers are usually not critical unless very responsive performance is required in which case empirical tuning would determine them.

By far, the most utilized approach has been linear weighting models. Linear weighting models place a weight on each criterion (typically subjectively determined) and provide a total score for each vendor by summing up the vendor's performance on the criteria multiplied by these weights. *Wind and Robinson (1968)* endorsed using a weighted linear model of multiple criteria for vendor selection. *Lamberson (1976) and Mazurak (1985). Timmerman (1986) and Gregory (1986)* have linked this approach to a matrix representation of data. *Cooper (1977) and Roberts (1978)* used linear weighting models to evaluate vendors on delivery performance. *Narasimhan (1983)* employed the analytical hierarchical process to generate weights for such models. *Monczka (1988)* developed multiple criteria vendor service factor ratings and an overall supplier performance index using linear weighting models. Given the inherent importance and complexity of vendor selection, then some articles proposed the use of mathematical programming techniques for vendor selection and order quantity decisions. The proposed techniques are linear programming, mixed integer programming, and goal programming.

Moore and Fearon (1973) were the first, to discuss the possible use of linear programming models for vendor selection. While the article did not provide an actual mathematical formulation, the objective of the conceptual model was to optimize the mix of vendor awards based on price, with constraints relating to the amount of business that any vendor could be awarded. *Anthony and Buffa (1977)* formulated a linear programming model to minimize total purchasing and storage costs in the scheduling of vendor deliveries. This model included budget, demand satisfaction and storage capacity constraints. *Kingsman (1988)* proposed, but did not formulate, the use of linear programming for commodity buying situations. *Pan (1989)* formulated a linear programming model to minimize total purchase price. This model included constraints on quality, lead time and service. *Gaballa (1974)* formulated mixed integer optimization models to determine vendors and order quantities for two classes of items ordered by the Australian Post Office. The objective in these models was to minimize total purchase costs where price and value discounts were present. *Bender et al. (1985)* described, but did not formulate, a mixed integer optimization model to minimize the sum of purchasing, transportation and inventory costs over multiple time periods. The model is constrained by vendor capacity and policy constraints. *Shapiro (1985)* proposed a MIP approach with the objective of minimizing purchasing, inventory and transportation related costs without any specific mathematical formulation and demonstrated it through selecting the vendors at IBM. *Narasimhan and Stoynoff (1986)* formulated a mixed integer optimization model to determine vendors and order quantities for multiple production plants. The objective in this model is to minimize the sum of total costs associated with transportation and inefficient utilization of vendor capacities. Constraints in the model address demand satisfaction, contract requirements and vendor capacities. *Turner (1988)* discussed a mixed integer optimization model used by British Coal for vendor selection. The objective in this model is to minimize total contract cost. Constraints in this model address demand satisfaction, vendor capacities, minimum and maximum order quantities, and geographic region purchasing constraints. *Ghodsypour and O'Brien (2001)* developed a mixed integer non-linear programming model to solve a multiple sourcing problem, which considers total cost of logistics with constraints on budget, quality, service, etc.

Vendor selection problem in terms of multi-objective mathematical programming techniques were formulated by *Buffa and Jackson (1983)*. Goals in the model addressed quality, price, and delivery criteria. *Sharma et al. (1989)* also formulated the problem as a goal program. Goals in the model addressed price, quality, lead time, demand and budget considerations. The third category, statistical approaches, was used by *Hinkle et al. (1969)* used cluster analysis to generate vendor ratings. *Ronen and Trietsch (1988)* developed a stochastic EOQ model as part of a decision support system for purchasing of items for large projects. *Soukup (1987)* modified the linear weighting method by using probabilities for the criterion weights. *Gao and Tang (2003)* proposed a multi-objective linear programming model for decisions related to purchasing of raw materials in a large-scale steel plant in China.

Liu, Ding, and Lall (2000) and Weber, Current, & Desai (2000) presented a data envelopment analysis method for a VSP (Vendor selection problem) with multiple objectives. *Handfield, Walton, Sroufe, and Melnyk (2002) and Narsimhan (1983)* used the analytical hierarchical process to generate weights for VSP. *Ghodsypour and O'Brien (1998)* developed a decision support system by integrating the analytical hierarchy process with linear programming. *Ronen and Trietsch (1988)* incorporated uncertainty and proposed a statistical model for VSP*. Kumar, Vrat, and Shankar (2002)* analyzed the effect of information uncertainty in the VSP with interval objective coefficients. *Feng, Wang, and Wang (2001)* presented a stochastic integer programming model for simultaneous selection of tolerances and suppliers based on the quality loss function and process capability index. Fuzzy goal programming approach has been used to deal with the effect of information uncertainty in the decisions involved in VSP *(Kumar et al., 2004). Ghodsypour and O'Brien (1998)* developed decision support system by integrating approach of analytical hierarchy process and linear programming.

The deterministic models proposed in literature suffer from the limitation in a real VSP due to the fact that a decision maker does not have sufficient information related to the different criteria. These data are typically fuzzy in nature. For a VSP, values of many criteria are expressed in imprecise terms like 'very poor in late deliveries', 'hardly any rejected items', etc. All the above-referred deterministic methods lack the capability to handle the linguistic vagueness of the data. The optimal results obtained from these deterministic formulations may not serve the real purpose of modeling the problem. So, we are required an intelligent system that can handle these problems and make the decisions based on the past experience from same type of problems.

2.4 Neural network programming approach for vendor attributes selection

Artificial Neural Networks (ANNs) is an abstract simulation of a real nervous system that contains a collection of neuron units communicating with each other via axon connections. Such a model bears a strong resemblance to axons and dendrites in a nervous system.

The first fundamental modeling of neural nets was proposed by *McCulloch and Pitts (1943)* in terms of a computational model of "nervous activity". The McCulloch-Pitts neuron is a binary device and each neuron has fixed threshold logic. This model leads the works of *Jhon von Neumann, Marvin Minsky*, *Frank Rosenblatt*, and many others.

Hebb postulated, in his classical book *The Organization of Behavior*, that the neurons were appropriately interconnected by self-organization and that "an existing pathway strengthens the connections between the neurons". He proposed that the connectivity of the brain is continually changing as an organism learns different functional tasks, and that cells assemblies are created by such changes. By embedding a vast number of simple neurons in an interactive nervous system, it is possible to provide computational power for very sophisticated information processing.

In this project data has beem collected from various companies with the help of a questionnaire, and on the basis of that data, started the learning of neural network once the learning is complete the network has become capable of making the decisions based on the learning.

Chapter 3

METHODOLOGY

3.1 Introduction: - The vendor selection process has undergone significant changes during the past twenty years. These include increased quality guidelines, improved computer communications, and increased technical capabilities. Given radical changes in the purchasing selection process, so we are required to use intelligent tools and techniques that can handle large amount of variables, and able to produce optimum results. So, I developed an intelligent system based on Artificial Neural Networks which can instantly reply to the need of buyer in order to identify the characteristics of vendor based on a number of parameters related to the Market conditions, Product conditions, Item consideration and Logistics consideration etc. The industrial world has a lot to gain from neural networks. Their ability to learn by example makes them very flexible and powerful. Furthermore there is no need to devise an algorithm in order to perform a specific task; i.e. there is no need to understand the internal mechanisms of that task. They are also very well suited for real time systems because of their fast response and computational times which are due to their parallel architecture.

This chapter is an introduction and application of Artificial Neural Networks. And a brief overview of various research works on neural networks and their areas of application are presented. Then the various types of neural networks are explained and demonstrated. The connection between the artificial and the real thing is also investigated and explained. Finally, the mathematical models involved are presented and demonstrated.

3.2 Neural Network

An Artificial Neural Network (ANN) is an information processing paradigm that is inspired by the way biological nervous systems, such as the brain, process information. The key element of this paradigm is the novel structure of the information processing system. It is composed of a large number of highly interconnected processing elements (neurons) working in unison to solve specific problems. ANNs, like people, learn by example. An ANN is configured for a specific application, such as identity selection, pattern recognition or data classification, through a learning process. Learning in biological systems involves adjustments to the synaptic connections that exist between the neurons. This is true of ANNs as well.

3.2.1 Historical background

Neural network simulations appear to be a recent development. However, this field was established before the advent of computers, and has survived at least one major setback and several eras. Many important advances have been boosted by the use of inexpensive computer emulations. Following an initial period of enthusiasm, the field survived a period of frustration and disrepute. During this period when funding and professional support was minimal, important advances were made by relatively few researchers. These pioneers were able to develop convincing technology which surpassed the limitations identified by Minsky and Papert (1969). Minsky and Papert, published a book in which they summed up a general feeling of frustration (against neural networks) among researchers, and was thus accepted by most without further analysis. Currently, the neural network field enjoys a resurgence of interest and a corresponding increase in funding.

The first artificial neuron was produced in 1943 by the neurophysiologist Warren McCulloch and the logician Walter Pits. Then they were followed by Donald Hebb. The first practical application of artificial neural networks came in the late 1950s, with the invention of the perceptron network and associated learning rule by Frank Rosenblatt. Rosenblatt and his colleagues built a perceptron network and demonstrated its ability to perform pattern recognition. At about the same time, Bernard Widrow and Ted Hoff introduced a new learning algorithm and used it to train adaptive linear neural networks, which were similar in structure and capability to Rosenblatt perceptron. Then Teuvo Kohonen and James Anderson independently and separately developed new neural networks that could act as memories. Stephen Grossberg [was also very active during this period in the investigation of self-organizing networks.

Interest in neural networks had faltered during the late 1960s because of the lack of new ideas and powerful computers with which to experiment. During the 1980s both of these impediments were overcome, and research in neural networks increased dramatically. New personal computers and workstations, which rapidly grew in capability, became widely available.

Two new concepts were most responsible for the rebirth of neural networks. The first was the use of statistical mechanics to explain the operation of a certain class of recurrent network, which could be used as an associative memory. This was described in a seminal paper by physicist John Hopfield. The second key development of the 1980s was the back propagation algorithm for training multilayer perceptron networks, which was discovered independently by several different researchers. The most influential publication of the back propagation algorithm was by David Rumelhart and James McClelland.

3.2.2 Advantage of neural networks

Neural networks, with their remarkable ability to derive meaning from complicated or imprecise data, can be used to extract patterns and detect trends that are too complex to be noticed by either humans or other computer techniques. A trained neural network can be thought of as an "expert" in the category of information it has been given to analyze. This expert can then be used to provide projections given new situations of interest and answer "what if"questions.

Other advantages include:

1. Adaptive learning: An ability to learn how to do tasks based on the data given for training or initial experience.
2. Self-Organization: An ANN can create its own organization or representation of the information it receives during learning time.

3. Real Time Operation: ANN computations may be carried out in parallel, and special hardware devices are being designed and manufactured which take advantage of this capability.
4. Fault Tolerance via Redundant Information Coding: Partial destruction of a network leads to the corresponding degradation of performance. However, some network capabilities may be retained even with major network damage.

3.3 Human and Artificial Neurons

Much is still unknown about how the brain trains itself to process information, so theories abound. In the human brain, a typical neuron collects signals from others through a host of fine structures called *dendrites*. The neuron sends out spikes of electrical activity through a long, thin stand known as an *axon*, which splits into thousands of branches. At the end of each branch, a structure called a *synapse* converts the activity from the axon into electrical effects that inhibit or excite activity from the axon into electrical effects that inhibit or excite activity in the connected neurons. When a neuron receives excitatory input that is sufficiently large compared with its inhibitory input, it sends a spike of electrical activity down its axon. Learning occurs by changing the effectiveness of the synapses so that the influence of one neuron on another changes.

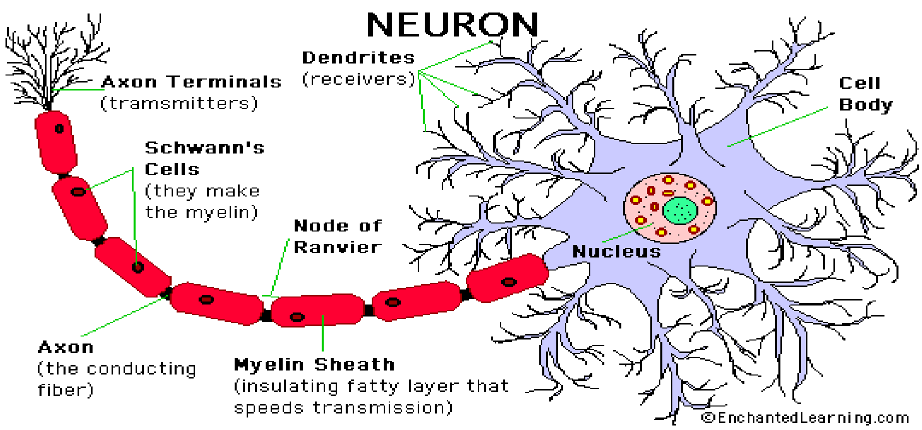


Fig 3.1 Human neuron

Artificial Neurons: - Neural networks are conducted by first trying to deduce the essential features of neurons and their interconnections. Then typically program a computer to simulate these features. However because our knowledge of neurons is incomplete and our computing power is limited, our models are necessarily gross idealizations of real networks of neurons. An artificial neuron is a device with many inputs and one output. The neuron has two modes of operation; the training mode and the using mode. In the training mode, the neuron can be trained to fire (or not), for particular input patterns.

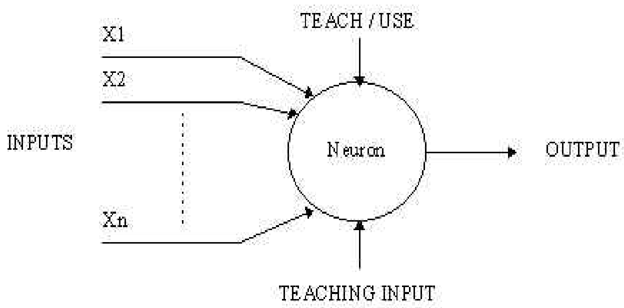


Fig 3.2 Simple neuron

In the using mode, when a taught input pattern is detected at the input, its associated output becomes the current output. If the input pattern does not belong in the taught list of input patterns, the firing rule is used to determine whether to fire or not.

3.3.1 Firing rules

The firing rule is an important concept in neural networks and accounts for their high flexibility. A firing rule determines how one calculates whether a neuron should fire for any input pattern. It relates to all the input patterns, not only the ones on which the node was trained.

A simple firing rule can be implemented by using Hamming distance technique. The rule goes as follows:

Take a collection of training patterns for a node, some of which cause it to fire (the 1-taught set of patterns) and others which prevent it from doing so (the 0-taught set). Then the patterns not in the collection cause the node to fire if, on comparison, they have more input elements in common with the 'nearest' pattern in the 1-taught set than with the 'nearest' pattern in the 0-taught set. If there is a tie, then the pattern remains in the undefined state.

For example, a 3-input neuron is taught to output 1 when the input (X1, X2 and X3) is 111 or 101 and to output 0 when the input is 000 or 001. Then, before applying the firing rule, the truth table is;

X1:		0	0	0	0	1	1	1	1
X2:		0	0	1	1	0	0	1	1
X3:		0	1	0	1	0	1	0	1
OUT:		0	0	0/1	0/1	0/1	1	0/1	1

As an example of the way the firing rule is applied, take the pattern 010. It differs from 000 in 1 element, from 001 in 2 elements, from 101 in 3 elements and from 111 in 2 elements. Therefore, the 'nearest' pattern is 000 which belongs in the 0-taught set. Thus the firing rule requires that the neuron should not fire when the input is 001. On the other hand, 011 is equally distant from two taught patterns that have different outputs and thus the output stays undefined (0/1). By applying the firing in every column the following truth table is obtained;

X1:		0	0	0	0	1	1	1	1
X2:		0	0	1	1	0	0	1	1
X3:		0	1	0	1	0	1	0	1
OUT:		0	0	0	0/1	0/1	1	1	1

The difference between the two truth tables is called the *generalization of the neuron.* Therefore the firing rule gives the neuron a sense of similarity and enables it to respond 'sensibly' to patterns not seen during training.

3.3.2 A more complicated neuron

The previous neuron doesn't do anything that conventional computers don't do already. A more sophisticated neuron is the McCulloch and Pitts model (MCP). The difference from the previous model is that the inputs are 'weighted' the effect that each input has at decision making is dependent on the weight of the particular input. The weight of an input is a number which when multiplied with the input gives the weighted input. These weighted inputs are then added together and if they exceed a pre-set threshold value, the neuron fires. In any other case the neuron does not fire.

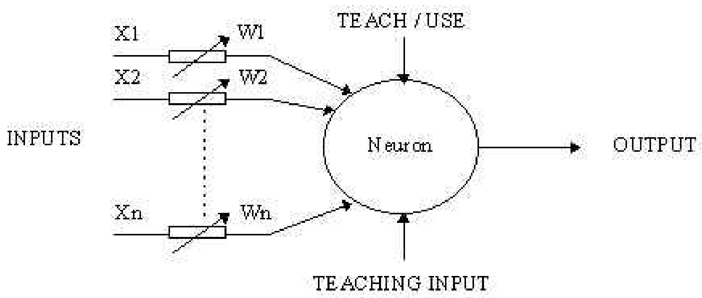


Fig 3.3 Complicated neuron

In mathematical terms, the neuron fires if and only if;

$X_1W_1 + X_2W_2 + X_3W_3 + ... > T$

The addition of input weights and of the threshold makes this neuron a very flexible and powerful one. The MCP neuron has the ability to adapt to a particular situation by changing its weights and/or threshold. Various algorithms exist that cause the neuron to 'adapt'; the most used ones are the Delta rule and the back error propagation. The former is used in feed-forward networks and the latter in feedback networks.

3.4 Architecture of neural networks

3.4.1 Feed-forward networks

Feed-forward Artificial Neural Networks (ANNs) allow signals to travel one way only; from input to output. There is no feedback (loops) i.e. the output of any layer does not affect that same layer. Feed-forward ANNs tend to be straight forward networks that associate inputs with outputs. They are extensively used in pattern recognition. This type of organization is also referred to as bottom-up or top-down.

3.4.2 Feedback networks

Feedback networks can have signals traveling in both directions by introducing loops in the network. Feedback networks are very powerful and can get extremely complicated. Feedback networks are dynamic; their 'state' is changing continuously until they reach an equilibrium point. They remain at the equilibrium point until the input changes and a new equilibrium needs to be found. Feedback architectures are also referred to as interactive or recurrent, although the latter term is often used to denote feedback connections in single-layer organizations.

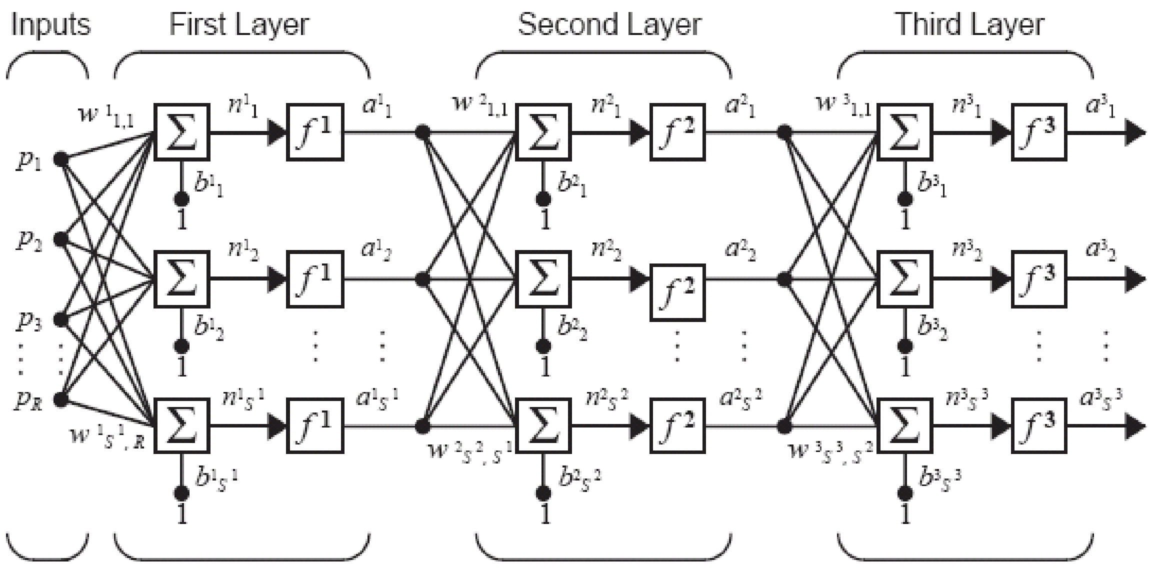


Fig 3.4 Simple feed forward network

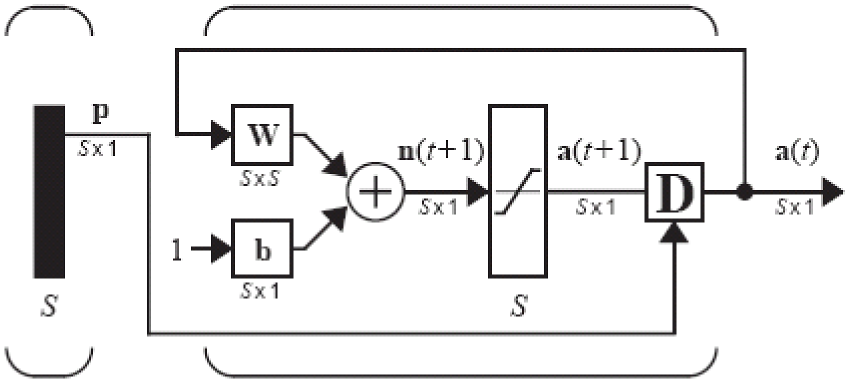


Fig 3.5 Complicated network

3.4.3 Network layers

The commonest type of artificial neural network consists of three groups, or layers, of units: a layer of "input" units is connected to a layer of "hidden" units, which is connected to a layer of "output" units.

- The activity of the input units represents the raw information that is fed into the network.
- The activity of each hidden unit is determined by the activities of the input units and the weights on the connections between the input and the hidden units.
- The behavior of the output units depends on the activity of the hidden units and the weights between the hidden and output units.

3.4.4 Perceptrons

The most influential work on neural nets in the 60's went under the heading of 'perceptrons' a term coined by Frank Rosenblatt. The perceptron turns out to be an MCP model (neuron with weighted inputs) with some additional, fixed, pre--processing. Perceptrons mimic the basic idea behind the mammalian visual system. They were mainly used in pattern recognition even though their capabilities extended a lot more.

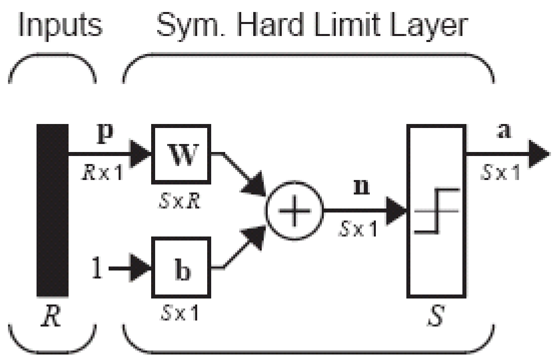


Fig 3.6 Perceptron

3.4.5 Learning Process

The memorization of patterns and the subsequent response of the network can be categorized into two general paradigms:

1) Associative mapping in which the network learns to produce a particular pattern on the set of input units whenever another particular pattern is applied on the set of input units. The associative mapping can generally be broken down into two mechanisms:

- *Auto-association*: an input pattern is associated with itself and the states of input and output units coincide. This is used to provide pattern completion, i.e. to produce a pattern whenever a portion of it or a distorted pattern is presented. In the second case, the network actually stores pairs of patterns building an association between two sets of patterns.
- *Hetero-association*: is related to two recall mechanisms:
  - *Nearest-neighbor* recall, where the output pattern produced corresponds to the input pattern stored, which is closest to the pattern presented, and Interpolative recall, where the output pattern is a similarity dependent interpolation of the patterns stored corresponding to the pattern presented. Yet another paradigm, which is a variant associative mapping, is

classification, i.e. when there is a fixed set of categories into which the input patterns are to be classified.

2) Regularity detection in which units learn to respond to particular properties of the input patterns. Whereas in associative mapping the network stores the relationships among patterns, in regularity detection the response of each unit has a particular 'meaning'. This type of learning mechanism is essential for feature discovery and knowledge representation.

Every neural network possesses knowledge which is contained in the values of the connections weights. Modifying the knowledge stored in the network as a function of experience implies a learning rule for changing the values of the weights.

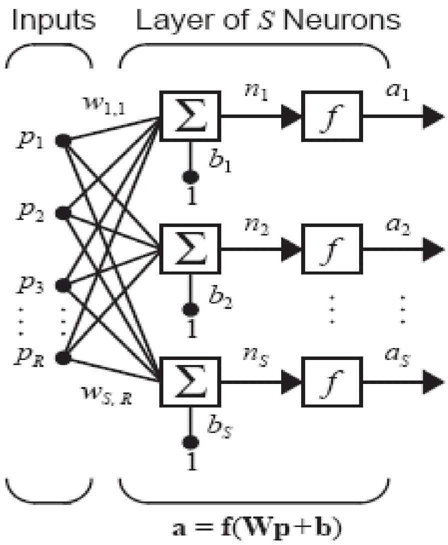


Fig 3.7 Learning of network

Information is stored in the weight matrix W of a neural network. Learning is the determination of the weights. Following the way learning is performed, we can distinguish two major categories of neural networks:

a) Fixed networks in which the weights cannot be changed, i.e. dW/dt=0. In such networks, the weights are fixed a priori according to the problem to solve.

b) Adaptive networks which are able to change their weights, i.e. dW/dt not= 0.

All learning methods used for adaptive neural networks can be classified into two major categories:

1) Supervised learning which incorporates an external teacher, so that each output unit is told what its desired response to input signals ought to be. During the learning process global information may be required. Paradigms of supervised learning include error-correction learning, reinforcement learning and stochastic learning. An important issue concerning supervised learning is the problem of error convergence, i.e. the minimization of error between the desired and computed unit values. The aim is to determine a set of weights which minimizes the error. One well-known method, which is common to many learning paradigms, is the least mean square (LMS) convergence.

2) Unsupervised learning uses no external teacher and is based upon only local information. It is also referred to as self-organization, in the sense that it self-organizes data presented to the network and detects their emergent collective properties. Paradigms of unsupervised learning are Hebbian learning and competitive learning. Human Neurons to Artificial Neuronesther aspect of learning concerns the distinction or not of a separate phase, during which the network is trained, and a subsequent operation phase. We say that a neural network learns off-line if the learning phase and the operation phase are distinct. A neural network learns on-line if it learns and operates at the same time. Usually, supervised learning is performed off-line, whereas unsupervised learning is performed on-line.

3.4.6 Transfer Function

The behavior of an ANN (Artificial Neural Network) depends on both the weights and the input-output function (transfer function) that is specified for the units. This function typically falls into one of three categories:

- Linear (or ramp)
- Threshold
- Sigmoid

For linear units, the output activity is proportional to the total weighted output.

For threshold units, the output are set at one of two levels, depending on whether the total input is greater than or less than some threshold value.

For sigmoid units, the output varies continuously but not linearly as the input changes. Sigmoid units bear a greater resemblance to real neurons than do linear or threshold units, but all three must be considered rough approximations.

To make a neural network that performs some specific task, we must choose how the units are connected to one another, and we must set the weights on the connections appropriately. The connections determine whether it is possible for one unit to influence another. The weights specify the strength of the influence.

We can teach a three-layer network to perform a particular task by using the following procedure:

1. We present the network with training examples, which consist of a pattern of activities for the input units together with the desired pattern of activities for the output units.
2. We determine how closely the actual output of the network matches the desired output.
3. We change the weight of each connection so that the network produces a better approximation of the desired output.

3.5 Mathematics of ANN:

We want to train a multi-layer feed forward network by gradient descent to approximate an unknown function, based on some training data consisting of pairs (x,t). The vector x represents a pattern of input to the network, and the vector t the corresponding target (desired output).

Definitions:

- The error signal for unit j: $\delta_j = -\partial E / \partial net_j$
- The (negative) gradient for weight w_{ij}: $\Delta w_{ij} = -\partial E / \partial w_{ij}$
- The set of nodes anterior to unit i: $A_i = \{j : \exists w_{ij}\}$
- The set of nodes posterior to unit j: $P_j = \{i : \exists w_{ij}\}$

Two factors by use of the chain rule:

$$\Delta w_{ij} = -\frac{\partial E}{\partial net_i} \frac{\partial net_i}{\partial w_{ij}}$$

The first factor is the error of unit i. The second is

$$\frac{\partial net_i}{\partial w_{ij}} = \frac{\partial}{\partial w_{ij}} \sum_{k \in A_i} w_{ik} y_k = y_j$$

Putting the two together, we get

$$\Delta w_{ij} = \delta_i y_j.$$

To compute this gradient, we thus need to know the activity and the error for all relevant nodes in the network.

Forward activation: The activity of the input units is determined by the network's external input **x**. For all other units, the activity is propagated forward:

$$y_i = f_i\left(\sum_{j \in A_i} w_{ij} y_j\right)$$

Note that before the activity of unit i can be calculated, the activity of all its anterior nodes (forming the set A_i) must be known. Since feed forward networks do not contain cycles, there is an ordering of nodes from input to output that respects this condition.

Calculating output error Assuming that we are using the sum-squared loss

$$E = \frac{1}{2}\sum_{o}(t_o - y_o)^2$$

the error for output unit is simply.

$$\delta_o = t_o - y_o$$

Error back propagation For hidden units, we must propagate the error back from the output nodes (hence the name of the algorithm). Again using the chain rule, we can expand the error of a hidden unit in terms of its posterior nodes:

$$\delta_j = -\sum_{i \in P_j} \frac{\partial E}{\partial net_i} \frac{\partial net_i}{\partial y_j} \frac{\partial y_j}{\partial net_j}$$

Of the three factors inside the sum, the first is just the error of node i. The second is

$$\frac{\partial net_i}{\partial y_j} = \frac{\partial}{\partial y_j} \sum_{k \in A_i} w_{ik} y_k = w_{ij}$$

While the third is the derivative of node j's activation function:

$$\frac{\partial y_j}{\partial net_j} = \frac{\partial f_j(net_j)}{\partial net_j} = f_j'(net_j)$$

For hidden units h that use the tanh activation function, we can make use of the special identity

$\tanh(u)' = 1 - \tanh(u)^2$, giving us

$$f_h'(net_h) = 1 - y_h^2$$

Putting all the pieces together we get

$$\delta_j = f_j'(net_j) \sum_{i \in P_j} \delta_i w_{ij}$$

Note that in order to calculate the error for unit j, we must first know the error of all its posterior nodes (forming the set P_j). Again, as long as there are no cycles in the network, there is an ordering of nodes from the output back to the input that respects this condition. For example, we can simply use the reverse of the order in which activity was propagated forward.

3.6 Applications of neural networks

Neural networks have broad applicability to real world problems. In fact, they have already been successfully applied in many industries. Since neural networks are best at identifying patterns or trends in data, they are well suited for almost all problems including:

Aerospace In Aero space it is used in high performance aircraft autopilots, flight path simulations, aircraft control systems, autopilot enhancements, aircraft component simulations, aircraft component fault detectors, Automobile automatic guidance systems, warranty activity analyzers. In Banking neural network is used to Checks and other document readers, credit application evaluators. In Defense it is can be used as Weapon steering, target tracking, object discrimination, facial recognition, new kinds of sensors, sonar, radar and image signal processing including data compression, feature extraction and noise suppression, signal/image identification. Neural networking can be extensively used in Electronics for Code sequence prediction, integrated circuit chip layout, process control, chip failure analysis, machine vision, voice synthesis, nonlinear modeling. In Entertainment world it can be used as a tool for Animation, special effects, market forecasting etc. Its application are also in

Financial for Real estate appraisal, loan advisor, mortgage screening, corporate bond rating, credit line use analysis, portfolio trading program, corporate financial analysis, currency price prediction. It can be used for Insurance Policy application evaluation, product optimization. In Manufacturing it is used for Manufacturing process control, product design and analysis, process and machine diagnosis, real-time particle identification, visual quality inspection systems, beer testing, welding quality analysis, paper quality prediction, computer chip quality analysis, analysis of grinding operations, chemical product design analysis, machine maintenance analysis, project bidding, planning and management, dynamic modeling of chemical process systems. Medical science can also take the benefit of neural networking in Breast cancer cell analysis, EEG and ECG analysis, prosthesis design, optimization of transplant times, hospital expense reduction, hospital quality improvement, and emergency room test advisement. It has a wide

application in Robotics like Trajectory control, forklift robot, manipulator controllers, and vision systems etc. it is also used for Speech recognition, speech compression, vowel classification, text to speech synthesis, Market analysis, automatic bond rating, stock trading advisory systems. In Telecommunications it is applied in Image and data compression, automated information services, real-time translation of spoken language, customer payment processing systems. In Transportation neural networking can be used as Truck brake diagnosis systems, vehicle scheduling, routing systems. Other areas of application of neural networking are: -

Table 3.1 Application of neural networks

S.No.	AREA OF APPLICATION	REMARKS
1	Production(cutting parameter opimization), Cus and Zuperl (2005)	In this paper, a neural network-based approach to complex optimization of cutting parameters is proposed. It describes the multi-objective technique of optimization of cutting conditions by means of the neural networks taking into consideration the technological, economic and organizational limitations. To reach higher precision of the predicted results, a neural optimization algorithm is developed and presented to ensure simple, fast and efficient optimization of all important turning parameters.
2	Production(tool condition monitoring in metal cutting), Dimla,Lister and Leighton(1996)	In this paper a review of tool condition monitoring (TCM) systems, developed or implemented through application of neural networks, is provided. The review seeks to illustrate the extent of application of neural networks and the need for multiple source sensor signals in TCM systems.
3	Production(cutting parameter optimization), Zuperl,Cus,Mursec and Ploj(2004)	In the contribution, a new hybrid optimization technique for complex optimization of cutting parameters is proposed. The developed approach is based on the maximum production rate criterion and incorporates 10 technological constraints. It describes the multi-objective technique of optimization of cutting conditions by means of the artificial neural network (ANN) and OPTIS routine by taking into consideration the technological, economic and organizational limitations.
4	Production(tool condition monitoring in metal cutting), Dimla and Lister(1999)	This paper outlines a neural networks based modular tool condition monitoring system for cutting tool state classification. Test cuts were conducted on EN24 alloy steel using P15 and P25 coated cemented carbide inserts and on-line cutting forces and vibration data acquired. Simultaneously the wear lengths on the cutting edges were measured, and these together with the processed data were fed to a neural network trained to distinguish tool-state.

5	Production(surface roughness prediction), Feng and Wang(2002)	The model considers the following working parameters: work-piece hardness (material), feed, cutter nose radius, spindle speed and depth of cut. Two competing data mining techniques, nonlinear regression analysis and computational neural networks, are applied in developing the empirical models. The values of surface roughness predicted by these models are then compared with those from some of the representative models in the literature. Metal cutting experiments and tests of hypothesis demonstrate that the models developed in this research have a satisfactory goodness of fit. It has also presented a rigorous procedure for model validation and model comparison.
6	Production(surface quality of molded parts), Erzurumlu and Oktem(2005)	In this study, response surface (RS) model and an artificial neural network (ANN) are developed to predict surface roughness values error on mold surfaces. In the development of predictive models, cutting parameters of feed, cutting speed, axial–radial depth of cut, and machining tolerance are considered as model variables. For this purpose, a number of machining experiments based on statistical threelevel full factorial design of experiments method are carried out in order to collect surface roughness values. An effective fourth order RS model is developed utilizing experimental measurements in the mold cavity. A feed forward neural network based on back-propagation is a multilayered architecture made up of one or more hidden layers (2 layers–42 neurons) placed between the input (1 layer–5 neurons) and output (1 layer-1 neuron) layers. The response surface model and an artificial neural network are compared with manufacturing problems such as computational cost, cutting forces, tool life, dimensional accuracy, etc.

7	Procedure presentation and operation validation in nuclear power plant, Mo,Lee and Seong(2007)	An operation guidance system (OGS) was developed to regulate and supervise operators' actions during abnormal environments in nuclear power plants (NPPs). The system integrated a primitive computerized procedures system (CPS) and an operation validation system (OVS) imbedded in a virtual simulated operational environment. As the key component of the OGS, OVS provided two important functions for the operators: validated check of operations, and qualitative and quantitative effects analysis of operations. Each of operators' action was evaluated by the system and possible results were simulated by using artificial neural networks (ANN). Finally, corresponding suggestion or warning was provided to operators.
8	Inspection(LED inspection system), Chen and Hsu(2007)	This paper presents neural-network-based recognition system for automatic light emitting diode (LED) inspection. Two types of neural- networks, back-propagation neural-network (BPNN) and radial basis function network (RBFN), are proposed and tested. The current– voltage (I–V) data from the LED inspection process is used for the network training and testing. This study adopts 300 random picking as network training and employs 100 samples as network testing. The experimental results show that if the classification work is done well, the accuracy of recognition is 100% for BPNN and 96% for RBFN, and the testing speed of the proposed approach is almost one half faster than the traditional inspection system does.
9	Medical(Image compression and segmentation), Dokur(2006)	This paper presents a novel unified framework for compression and decision making by using artificial neural networks. The proposed framework is applied to medical images like magnetic resonance (MR), computer tomography (CT) head images and ultrasound image. Two artificial neural networks, Kohonen map and incremental self-organizing map (ISOM), are comparatively examined.Compression and decision making processes are simultaneously realized by using artificial neural networks.

10	Civil(General application), Jeng,Cha and Blumenstein	In this paper, an artificial neural network (ANN) is applied to several civil engineering problems, which have difficulty to solve or interrupt through conventional approaches of engineering mechanics. These include tide forecasting, earthquake-induced liquefaction and wave-induced seabed instability. As shown in the examples, ANN model can provide reasonable accuracy for civil engineering problems, and a more effective tool for engineering applications.
11	Civil(design optimization of bridge decks), Srinivas and Ramanjaneyulu(2007)	The objective of this paper is to develop an integrated approach using artificial neural networks (ANN) and genetic algorithms (GA) for cost optimization of bridge deck configurations. In the present work, ANN is used to predict the structural design responses which are used further in evaluation of fitness and constraint violation in GA process. A multilayer back-propagation neural network is trained with the results obtained using grillage analysis program for different bridge deck configurations and the correlation between sectional parameters and design responses has been established. Subsequently, GA is employed for arriving at optimum configuration of the bridge deck system by minimizing the total cost.
12	Packaging, Huang and Hung(2006)	The aim of this study is to improve the lower warpage properties for 0.65 mm CSP assembly yield using a model based on a radial basis function network (RBFN), and the optimal HDD packaging process parameter design is achieved through a genetic algorithm (GA).

13	Civil (estimation of kinematic soil pile interaction response parameters), Ahmad,Naggar and Khan(2006)	Six artificial neural network (ANN) models are developed to predict various response parameters of kinematic soil pile interaction.These responses include (1) kinematic response factors for free and fixed head piles in homogenous soil layer to derive foundation inputmotion (2) normalized bending moment at fixed head of pile in homogenous soil layer (3) normalized kinematic pile moment at the interface of two soil layers of sharply different soil stiffnesses. These ANN models represent simple solutions that can be implemented ina simple calculator capable of matrix operation and bypass the site response analysis and the complex wave diffraction analysis.
14	Civil(water resource management), Iliadis and Marsi(2007)	This is a preliminary attempt towards a wider use of Artificial Neural Networks in the management of mountainous water supplies. It proposes a model to be used effectively in the estimation of the average annual water supply, in each mountainous watershed of Cyprus. This is really a crucial task, especially during the long dry summer months of the island. On the other hand the evaluation of the potential torrential risk due to high volume of water flow in the winter season is also very important. Data (from 1965e1993) from 78 measuring stations located in the 70 distinct watersheds of Cyprus were used. This data volume was divided in the training subset comprising of 60 cases and in the testing subset containing 18 cases. The input parameters are the area of the watershed, the average annual and the average monthly rain-height, the altitude and the slope in the location of the measuring station. Consequently three structural and two dynamic factors are considered. After several and extended training-testing efforts a Modular Artificial Neural Network was determined to be the optimal one.

15	Physics, Dimoulas,Kalliris,Papanikolaou,Petridis and Kalampakas (2006)	This work focuses on the implementation of an autonomous system appropriate for long-term, unsupervised monitoring of bowelsounds, captured by means of abdominal surface vibrations. The autonomous intestinal motility analysis system (AIMAS) promises to deliver new potentials in gastrointestinal auscultation, towards the establishment of novel non-invasive methods for prolonged intestinal monitoring and diagnosis over functional disorders. The system was developed utilizing time–frequency features and wavelet-adapted parameters in combination with multi-layer perceptrons, that exhibit remarkable adaptation in pattern classification applications.Various network topologies and sizes were tested in combination with different features' sets. Quantitative analysis and validation results showed that the implemented system exhibits an overall recognition accuracy of 94.84%, while the error in separating bowel sounds from other sound patterns, representing interfering noises, was 2.19%.
16	Forecasting, Hui(2007)	This study proposes a new method for predicting the reliability for repairable systems. The novel method constructs a predictive model by employing evolutionary neural network modeling approach. Genetic algorithms are used to globally optimize the number of neurons in the hidden layer and learning parameters of the neural network architecture.
17	Machining(stellite 6), Aykut,Golcu,Semiz and Ergur(2007)	In this study, artificial neural networks (ANNs) was used for modeling the effects of machinability on chip removal cutting parameters for face milling of stellite 6 in asymmetric milling processes. Cutting forces with three axes (Fx, Fy and Fz) were predicted by changing cutting speed (Vc), feed rate (f) and depth of cut (ap) under dry conditions. Experimental studies were carried out to obtain training and test data and scaled conjugate gradient (SCG) feed-forward back-propagation algorithm was used in the networks.

18	Thermal (Predictive temperature control), Aggelogiannaki,Sarimveis and Koubogiannis(2007)	In this paper, a nonlinear model predictive control (MPC) configuration for hyperbolic distributed thermal systems is presented and applied in the flow-based temperature control in a long duct. At first, a radial basis function neural network is developed to estimate the temperature distribution along the duct with respect to flow velocity, assuming constant ambient temperature. The nonlinear model is then incorporated in the context of an MPC procedure. The use of the neural network model avoids the spatial discretization and decreases significantly the computational effort required to solve the optimization problem that is formulated in real time, compared to conventional modeling approaches. The proposed MPC scheme is able to overcome delay effects and accelerates the outlet temperature response. Reduced tuning effort is another advantage of the proposed control scheme.
19	Thermal (Free Laminar convection heat transfer), Mahmoud and Nakhi(2005)	The feasibility of using neural networks (NNs) to predict the complete thermal and flow variables throughout a complicated domain, due to free convection, is demonstrated. Attention is focused on steady, laminar, two-dimensional, natural convective flow within a partitioned cavity. The objective is to use NN (trained on a database generated by a CFD analysis of the problem of a partitioned enclosure) to predict new cases; thus saving effort and computation time. Three types of NN are evaluated, namely General Regression NNs, Polynomial NNs, and a versatile design of Backpropagation neural networks. An important aspect of the study was optimizing network architecture in order to achieve best performance. For each of the three different NN architectures evaluated, parametric studies were performed to determine network parameters that best predict the flow variables.

20	Forging, Serajzadeh(2006)	In this work, a neural network model is used to calculate flow stress of deforming metal as a function of temperature, strain and strain rate. Then, with the aid of this model and employing a finite element analysis, flow behavior of material and the temperature variations in hot upsetting process are predicted. To examine the model, hot nonisothermal forging of low carbon steel is performed while force–displacement behavior during hot deformation is recorded. A good agreement is observed between the predicted data and the measured results.

3.7 Requirement of Neural Network in Vendor selection problem: - In vendor attribute selection we have a number of approaches as discussed in chapter two. All these approaches use a defined function, but with the help of given graphs we can see that there is no constant function exist between the attributes of buyer and vendor, hence a tool is required which can handle the fuzziness in the functions exist between the attributes of two. These graphs show the relationship between each buyer factor with six vendor attributes. On X axis vendor attributes are taken and on Y axis buyer factor is taken.

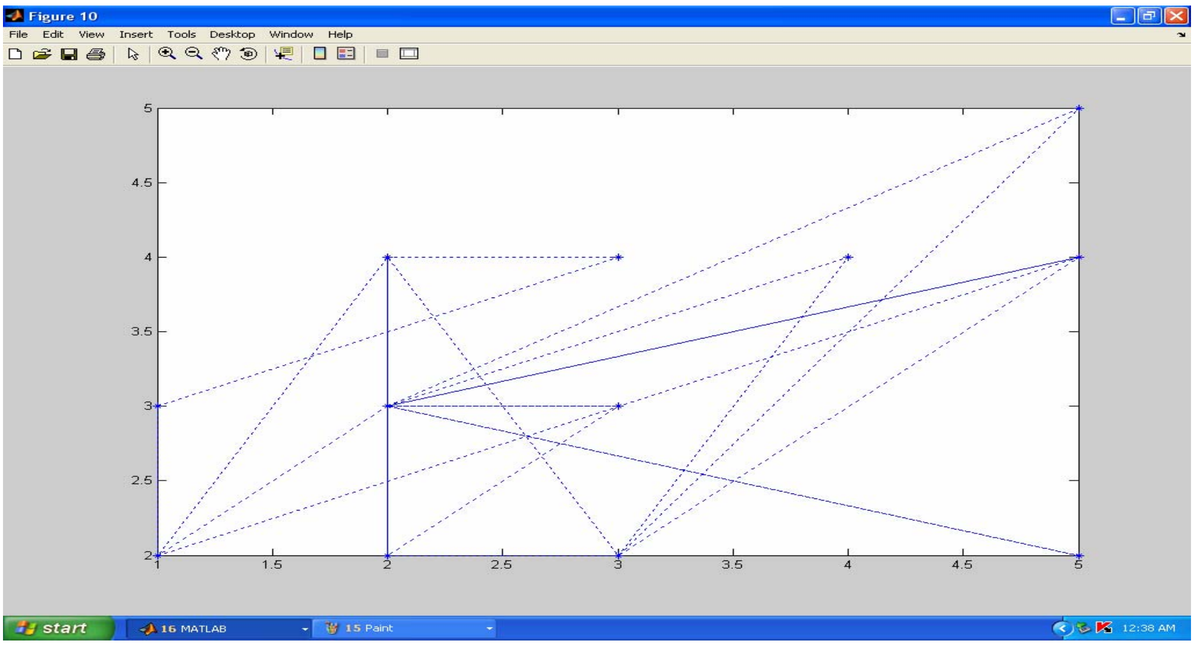


Fig 3.8 Relationship graph between value of purchased item (buyer attribute) to all vendor attributes

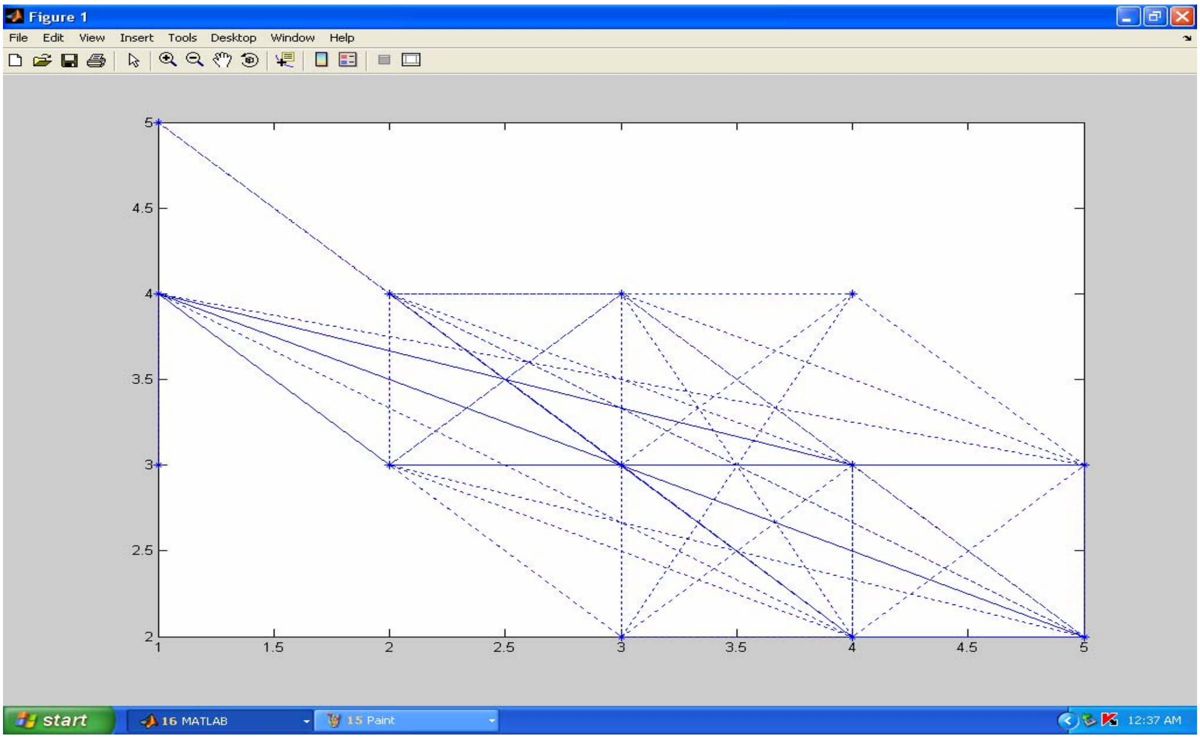


Fig 3.9 Relationship graph between volume of purchased item (buyer attribute) to all vendor attributes

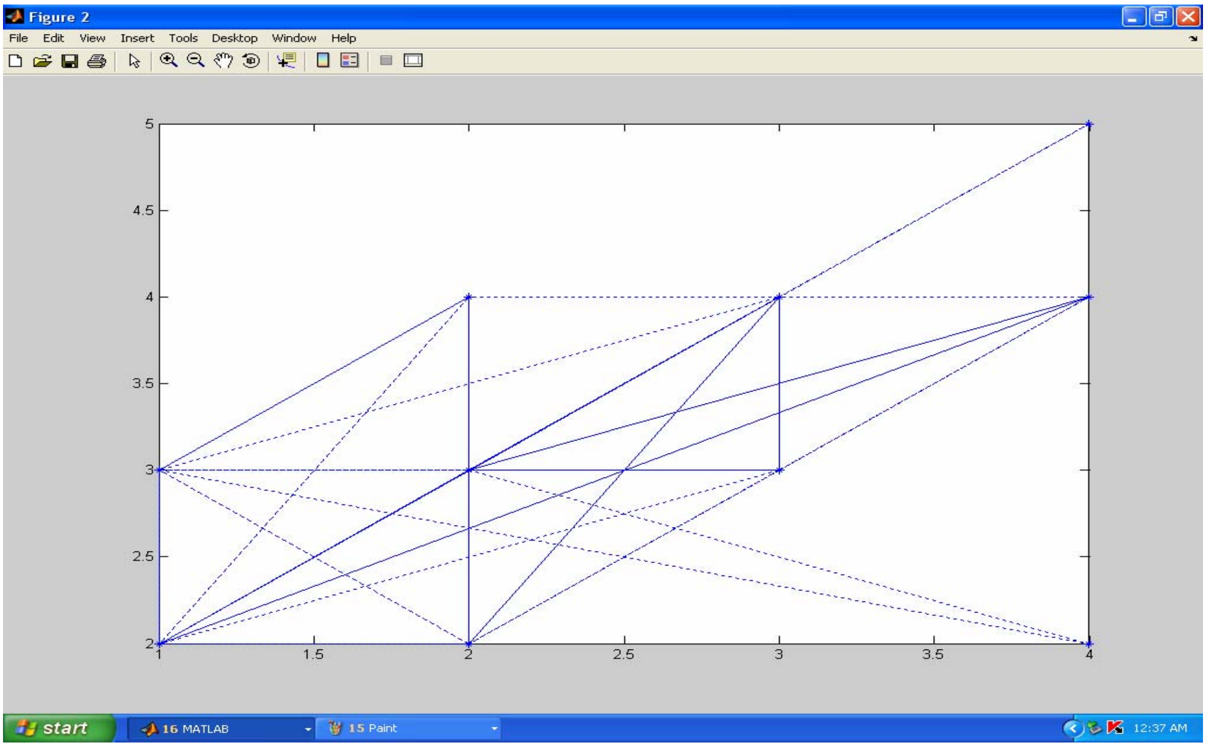


Fig 3.10 Relationship graph between criticality of item (buyer attribute) to all vendor attributes

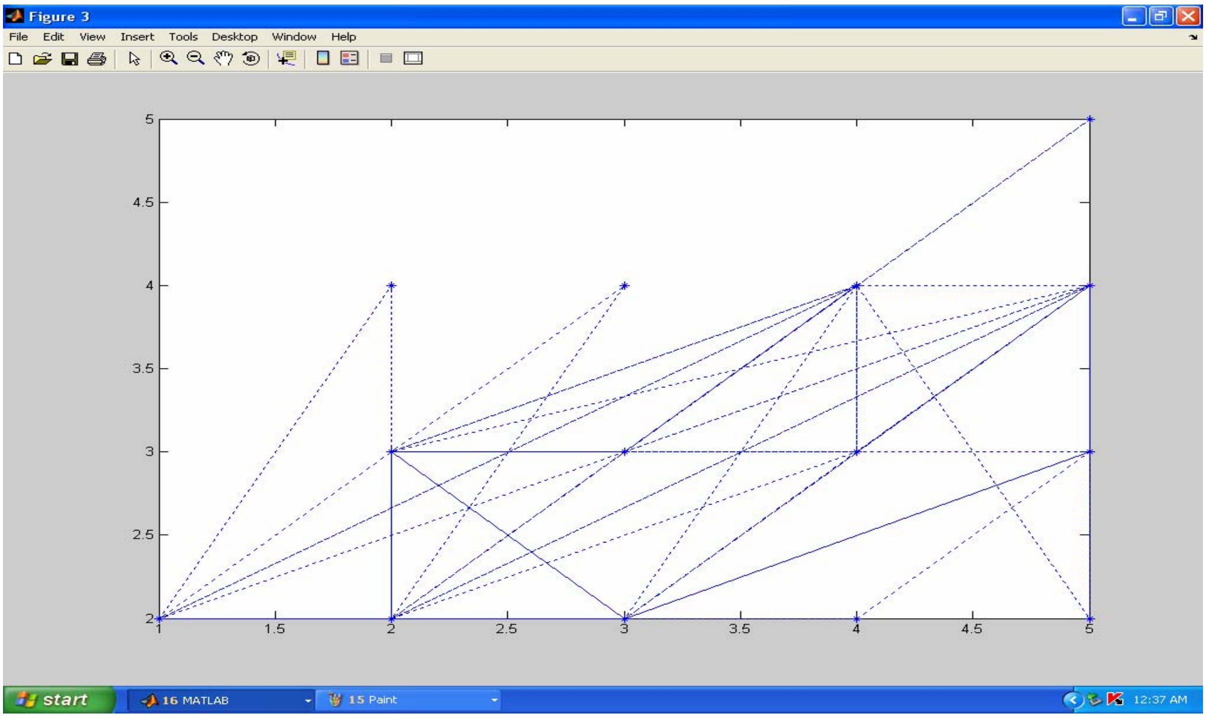


Fig 3.11 Relationship graph between No. of source of supply (buyer attribute) to all vendor attributes

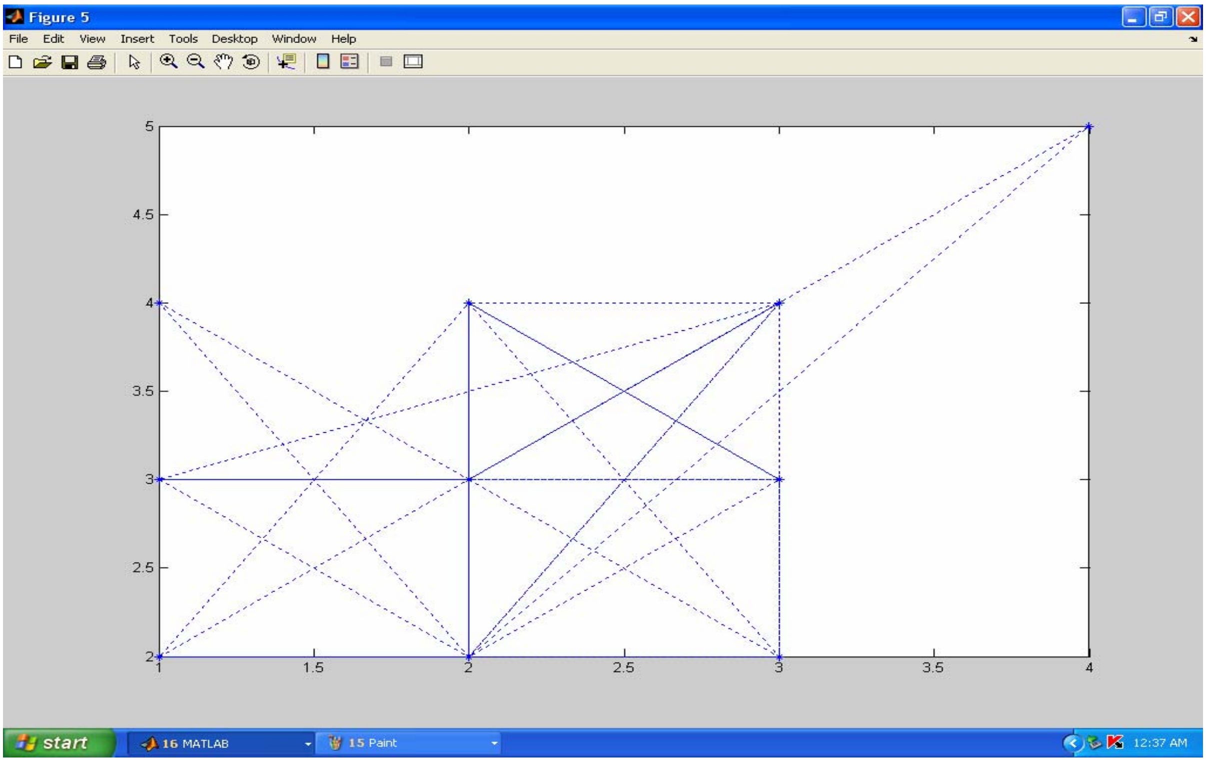


Fig 3.12 Relationship graph between Demand rate (buyer attribute) to all vendor attributes

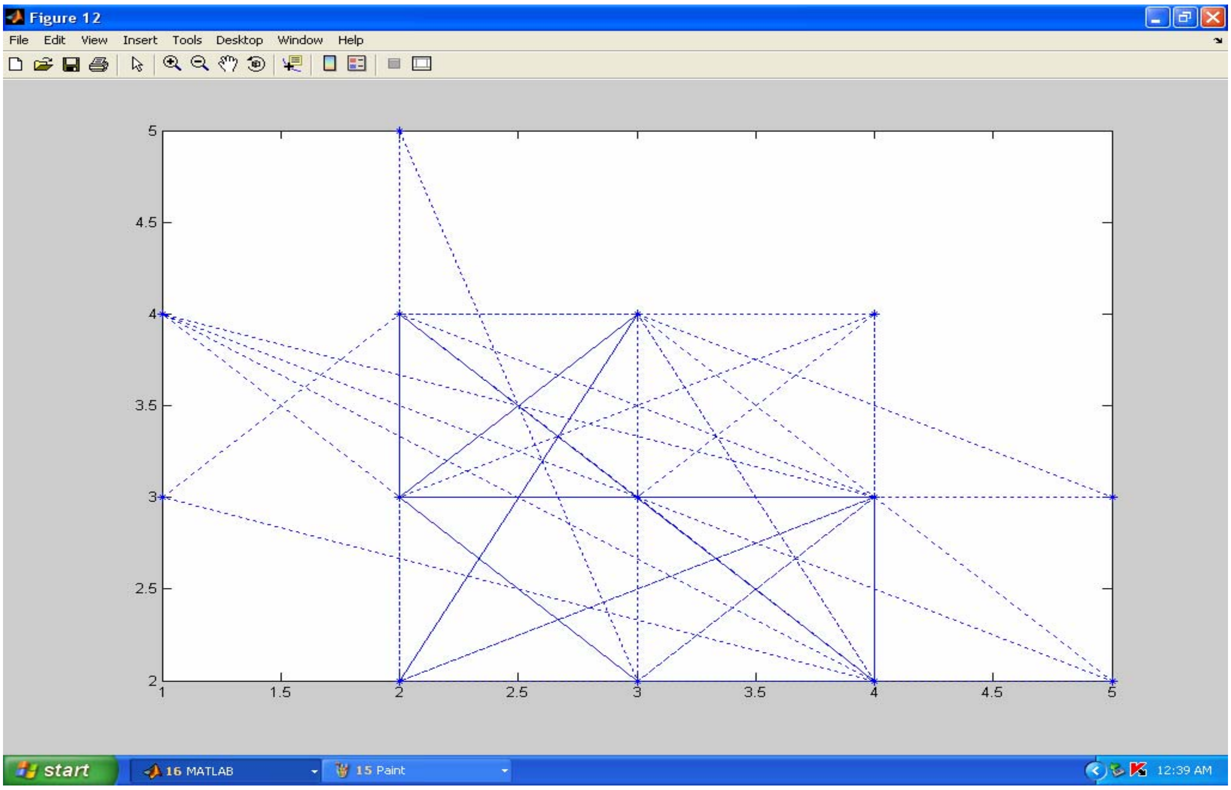


Fig 3.13 Relationship graph between Ease of transportation (buyer attribute) to all vendor attributes

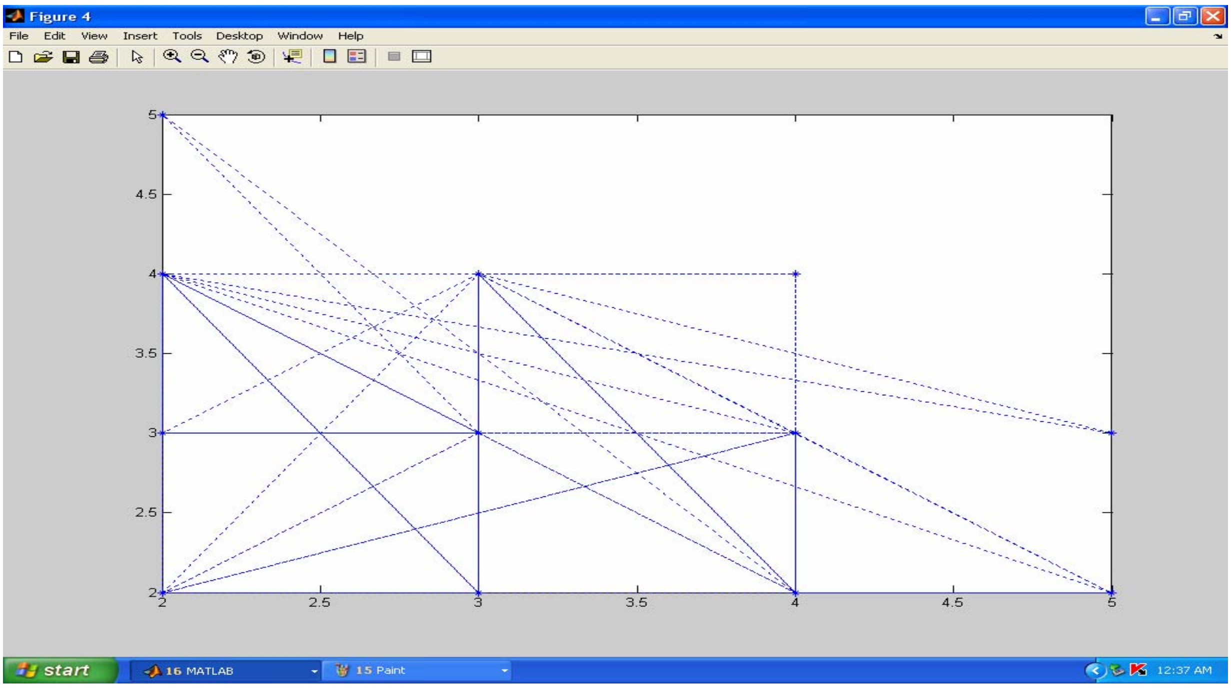


Fig 3.14 Relationship graph between Degree of engineering changes (buyer attribute) to all vendor attributes

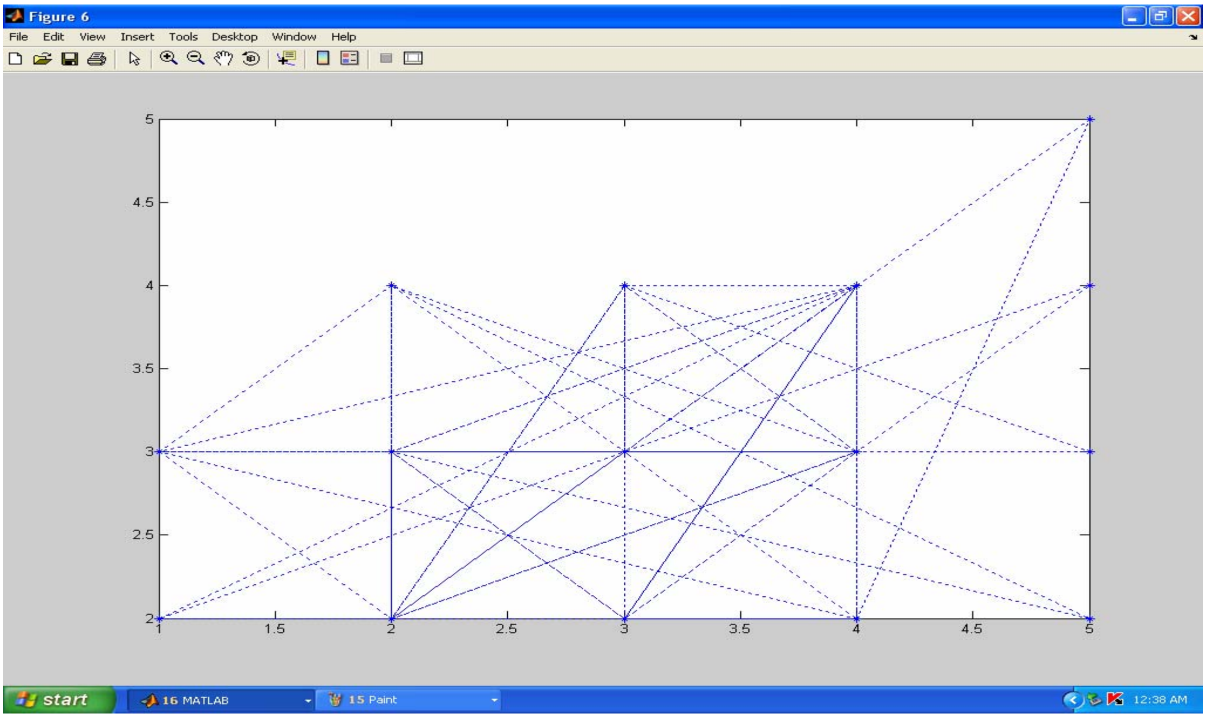


Fig 3.15 Relationship graph between Transportation cost (buyer attribute) to all vendor attributes

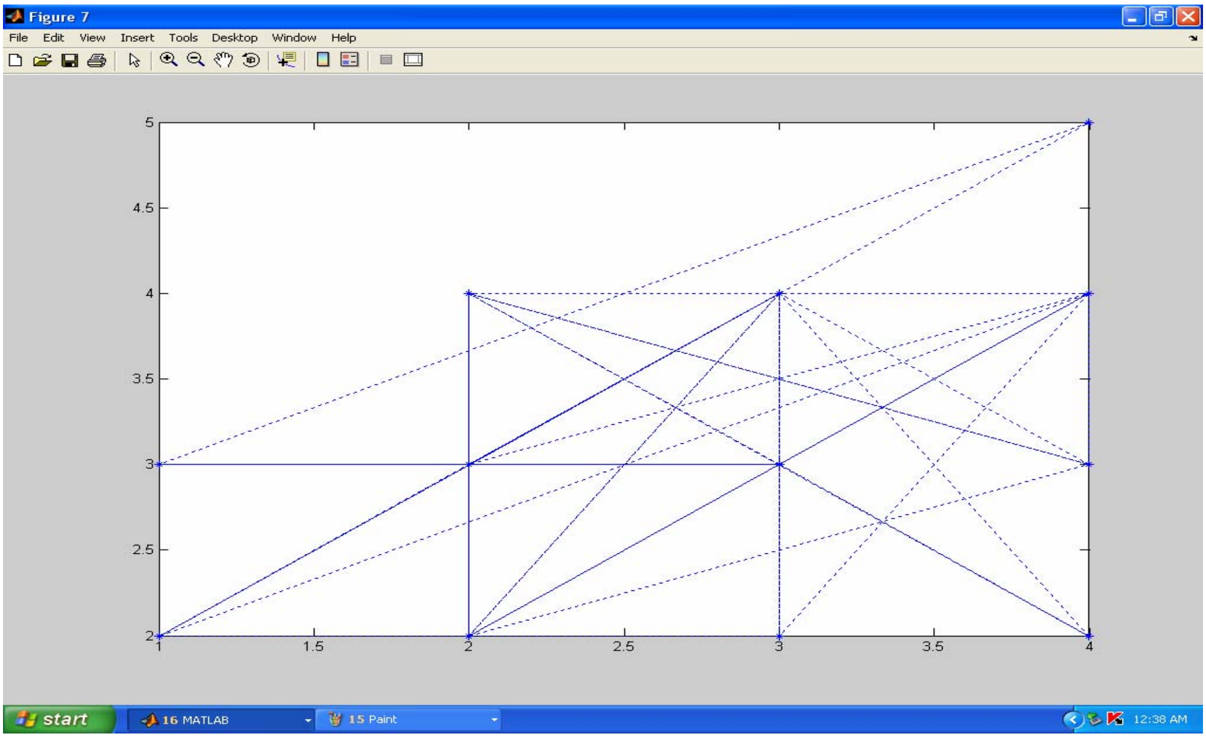


Fig 3.16 Relationship graph between End use of item (buyer attribute) to all vendor attributes

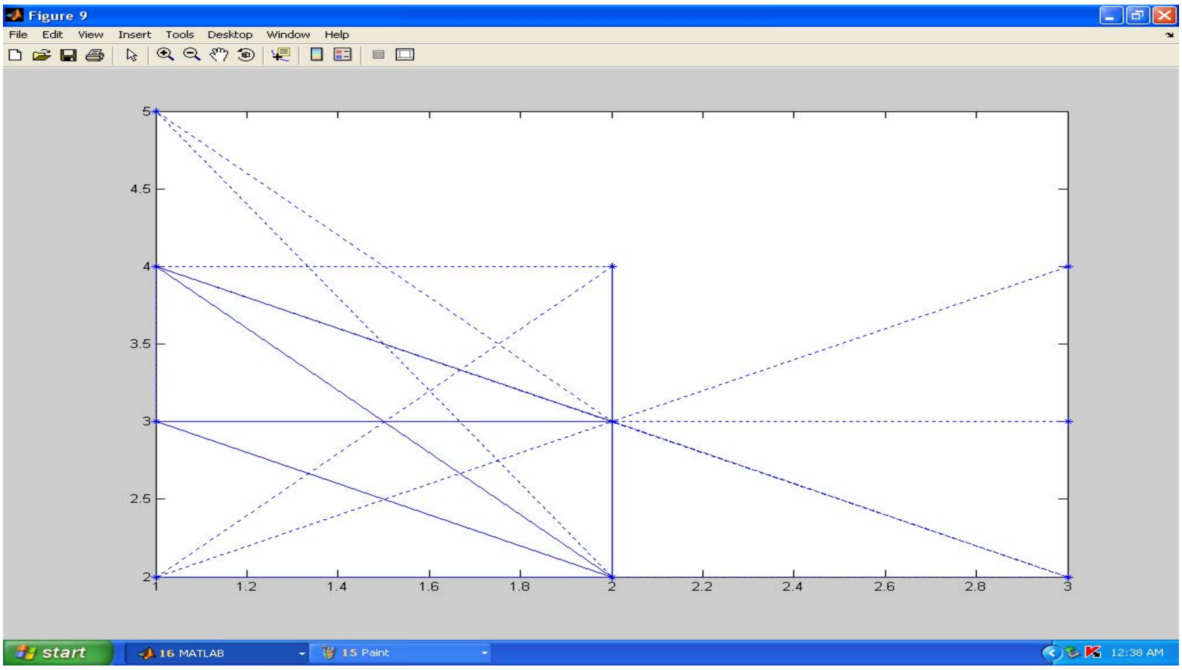


Fig 3.17 Relationship graph between Manufacturing Strategy (buyer attribute) to all vendor attributes

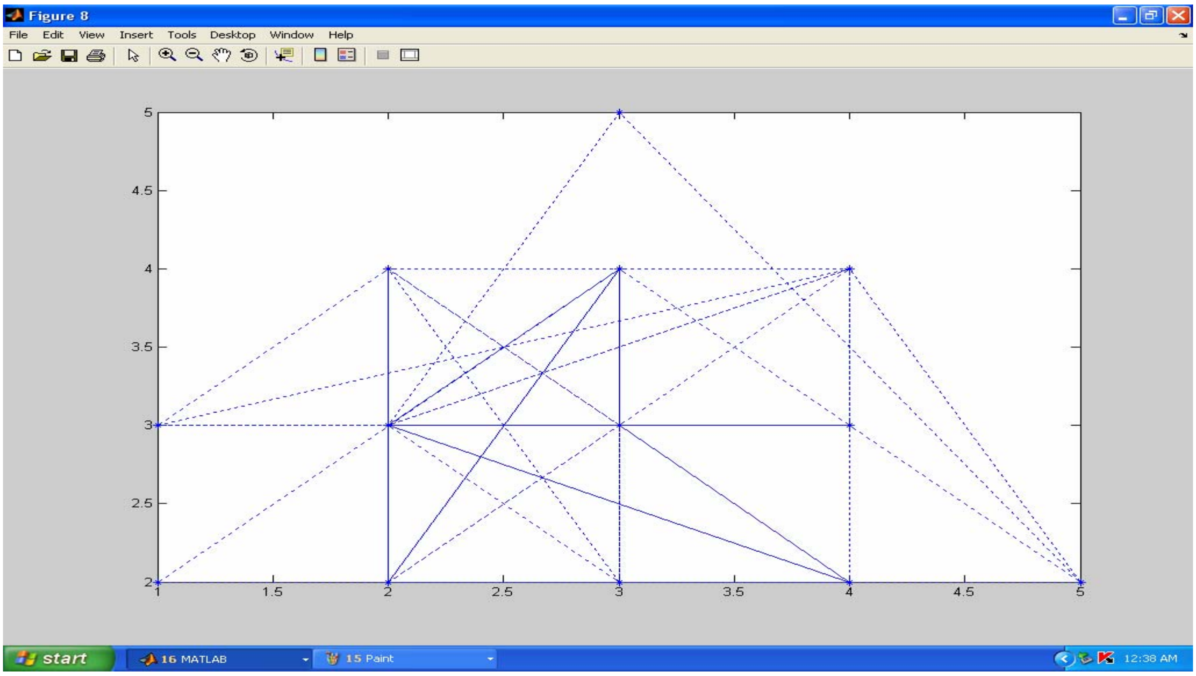


Fig 3.18 Relation ship graph between Ease of storage (buyer attribute) to all vendor attributes

So, by analyzing these graphs the fuzziness of the functions can be seen, but neural networking approach can easily handle this problem hence it is very useful .

Chapter 4

SELECTION OF VENDOR ATTRIBUTRS USING ANN

4.1 INTRODUCTION: - In the competitive market environment, it is very important for a company to keep its supply chain agile and flexible. Within the supply chain designing, supplier selection is a purchasing consideration of increasing importance and the supply activities have become one of the most critical factors in the creation of added value Wei Siying et.all. (1997). Therefore, efficient supplier selection seems to be more and more important to all company. They must select the suppliers that best fit for their own enterprises' needs and objectives. The key to enhance the quality of decision making in the supplier selection function is to utilize the powerful computer-aided tools and mathematic models. In the procedure of supplier selection, the first step is to determine the factors that affect the decision result. So in this project thirteen factors of buyer and six factors of vendor have been taken in consideration.

Buyer's factor: - These are the various buyers factor which are taken in consideration.

- Value of purchased item
- Volume of purchased item
- Criticality of item
- No. of source of supply
- Demand rate
- Ease of transportation
- Degree of engineering changes
- Transportation cost/time
- Transportation Reliability
- End use of item
- Manufacturing Strategy
- Ease of storage
- Life cycle stage

Vendor's factor: - These are the vendor factors which are taken in consideration

- Size of production facility
- Quality
- No. of clients
- Process capability
- Vendor location

4.2 NETWORK GENERATION

4.2.1 Introduction: - Artificial neural networking (ANN) is a tool in MATLAB, which is used to get the attribute of a vendor based upon the attributes of a buyer. Using neural networking a code is developed, with the help of this code ANN develops a network and this network gets training from the data which a used provides. Then this trained network can be used to select the attributes of a vendor. The use of this code is not only limited to the vendor attributes selection but it can be used for various other problems where the multi criterion decision making is involved. In such cases the user is required to train the network as per the available data and based on that learning, the network will start producing results.

4.2.2 Scope: - The scope of the application is inside any manufacturing organization and in particular within department namely, planning purchase and dispatch. Although this code is custom build to meet the requirement of vendor attribute selection, but similar efforts can be extended to any other problem with multiple criterion decision making with some modification.

4.2.3 System overview: - The use of this software is very simple, user is required to write the input in excel file and call the input file in the network. It will produce the results in the terms of excel files and graphs. The hardware requirements of this application are:-

Processor- Intel P IV 2.2 GHz

Cache- 1MB

RAM – 256 MB

The software requirements are:-

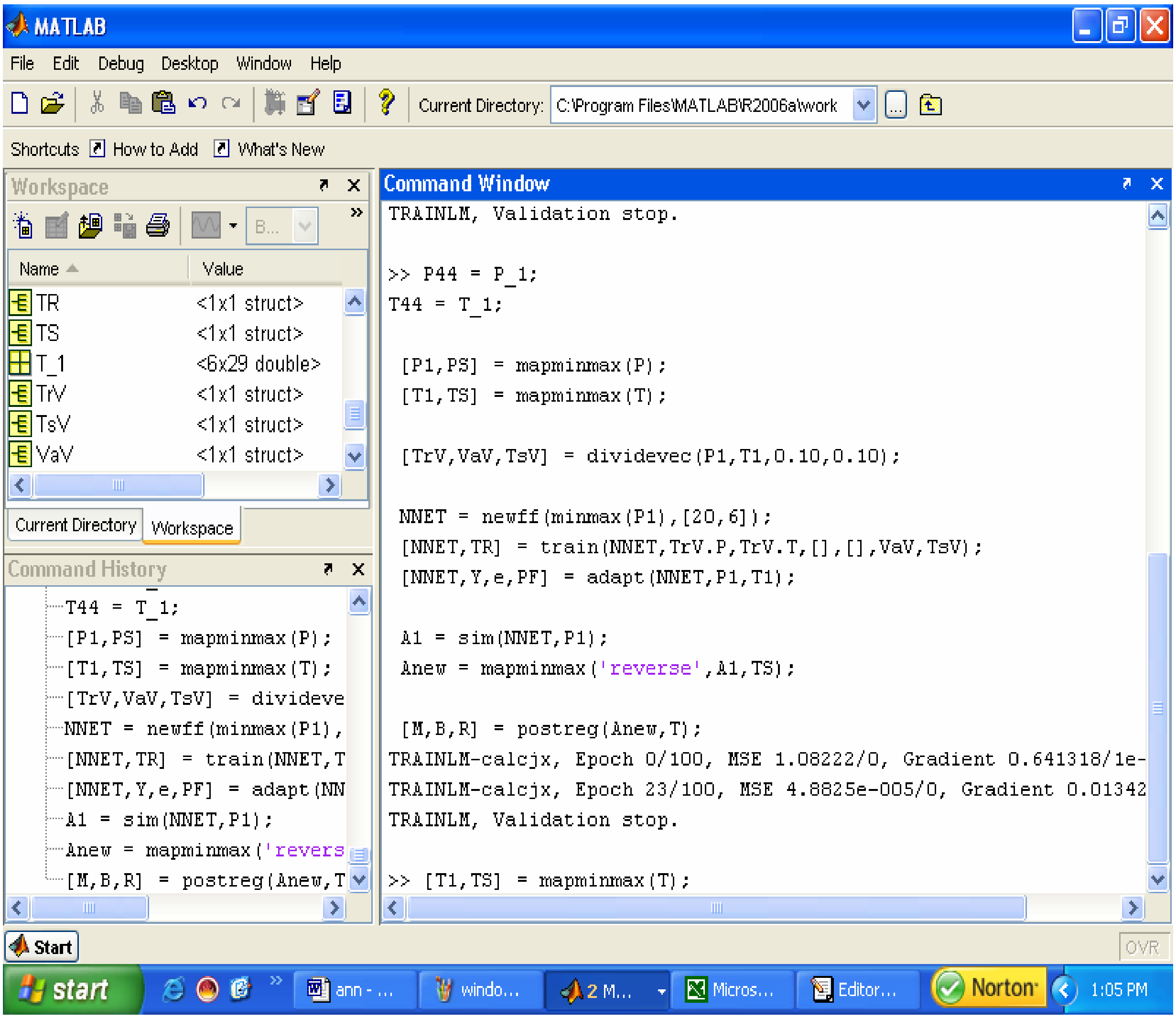
Operating system- Windos98/ Me/ NT/ 2000/ XP

Communication interface- Excel

Development interface- MATLAB

Window of MATLAB is shown below.

Figure 4.1 Matlab window



4.3 CODE FILE:- The code is written in MATLAB and is as follows:

```
function [net,ps,ts] = fitwithnet(p,t)
%FITWITHNET Creates and trains a neural network to fit input/target data.
%
```

```
%    [NET,PS,TS] = FITWITHNET(P,T) takes:
%    P - RxQ matrix of Q R-element input samples
%    T - SxQ matrix of Q S-element associated target samples
%    arranged as columns, and returns these results:
%    NET - The trained neural network
%    PS - Settings for preprocessing network inputs with MAPMINMAX.
%    TS - Settings for postprocessing network outputs with MAPMINMAX.
%
%    For example, to create an network with this function:
%
%    load housing
%    [net,ps,ts] = fitwithnet(p,t);
%
%  To test the network on the original or new data:
%
%    pn = mapminmax('apply',p,ps); % Preprocess inputs
%    an = sim(net,pn); % Apply network
%    a = mapminmax('reverse',an,ts); % Postprocess outputs
%    e = t - a; % Compare targets and outputs
%
%
%    [net,ps,ts] = fitwithnet(P10,T_1);



rand('seed',1.553630741E9)

% Normalize Inputs and Targets
[normInput,ps] = mapminmax(p);
[normTarget,ts] = mapminmax(t);

% Create Network
numInputs = size(p,1);
```

```
numHiddenNeurons = 20;  % Adjust as desired
numOutputs = size(t,1);
net = newff(minmax(normInput),[numHiddenNeurons,numOutputs]);

% Divide up Samples
testPercent = 0.10;  % Adjust as desired
validatePercent = 0.10;  % Adust as desired

[trainSamples,validateSamples,testSamples] =
dividevec(normInput,normTarget,testPercent,validatePercent);

% Train Network
[net,tr] = train(net,trainSamples.P,trainSamples.T,[ ],[
],validateSamples,testSamples);

 % Simulate Network
[normTrainOutput,Pf,Af,E,trainPerf] = sim(net,trainSamples.P,[ ],[ ],
trainSamples.T);

[normValidateOutput,Pf,Af,E,validatePerf] = sim(net,validateSamples.P,[ ],[ ],
validateSamples.T);

[normTestOutput,Pf,Af,E,testPerf] = sim(net,testSamples.P,[ ],[
],testSamples.T);

% Reverse Normalize Outputs
trainOutput = mapminmax('reverse',normTrainOutput,ts);
validateOutput = mapminmax('reverse',normValidateOutput,ts);
testOutput = mapminmax('reverse',normTestOutput,ts);

% Plot Regression
figure
postreg({trainOutput,validateOutput,testOutput}, ...
```

```
{t(:,trainSamples.indices),t(:,validateSamples.indices),t(:,testSamples.indices)});
```

4.4 Network Learning: - On the basis of the code given, artificial neural network will develop a network and now it is required to make the network learn. So the data collected from various companies will be feed in the network and learning of the network will be started for learning data is taken from more than fifteen companies (list given in annexure). Learning Data is given in table 4.1, in the learning data each column shows a sample i.e. buyer and vendor characteristics for a particular product.

TRAINING GRAPH:-Training graph of the data in table 4.1 is presented in figure 4.2. This is generated with the help of Neural Networking. When a network get trained, it is required to define the percentage of train data, validation data, test data so that the network can itself validate and test its own training. This graph shows that how the training is progressing in each Epoch (regression) and consequently validation and test of network is in progress after 13 epochs training is complete as the nature of test data and validation data has become same.

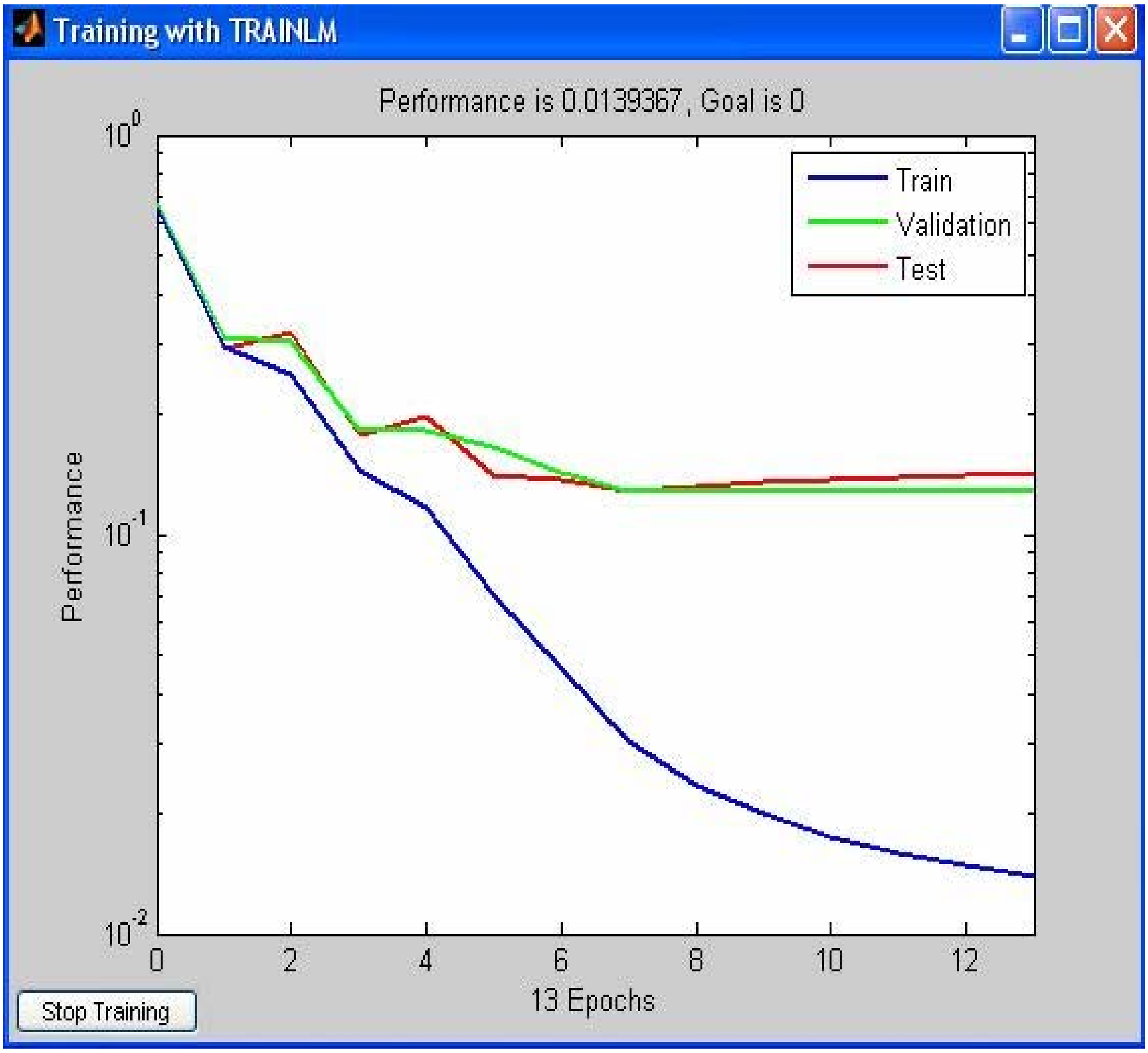


Fig 4.2 Training Graph

REGRESSION GRAPHS:- Figure 4.3 to figure 4.5 shows the regression graphs of learning data, validation data and test data. In these graphs the dotted line shows A(output) = T (target) i.e. the ideal condition. While the dots show the actual output for particular sample and based on that a best fit line is drawn the best fit line should be as close as the dotted line.

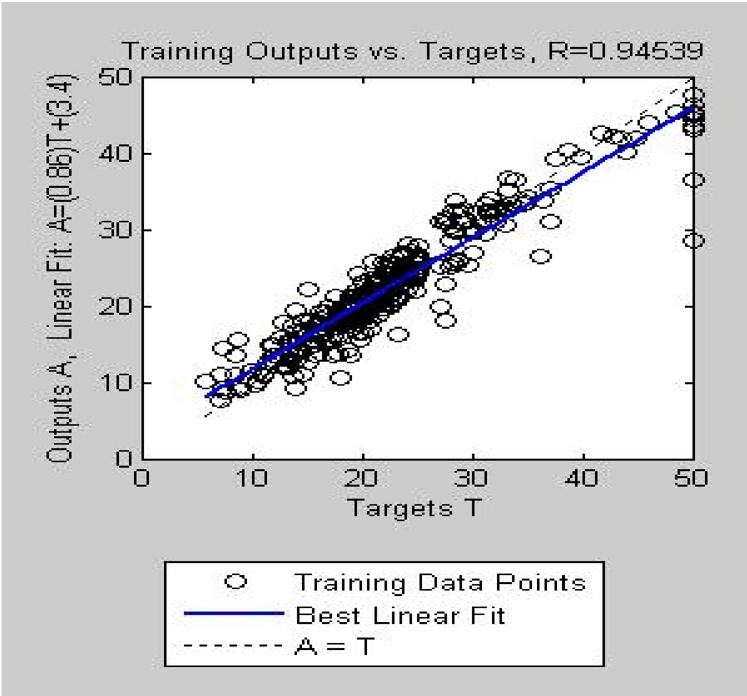


Fig 4.3 Regression Coefficient of learning data

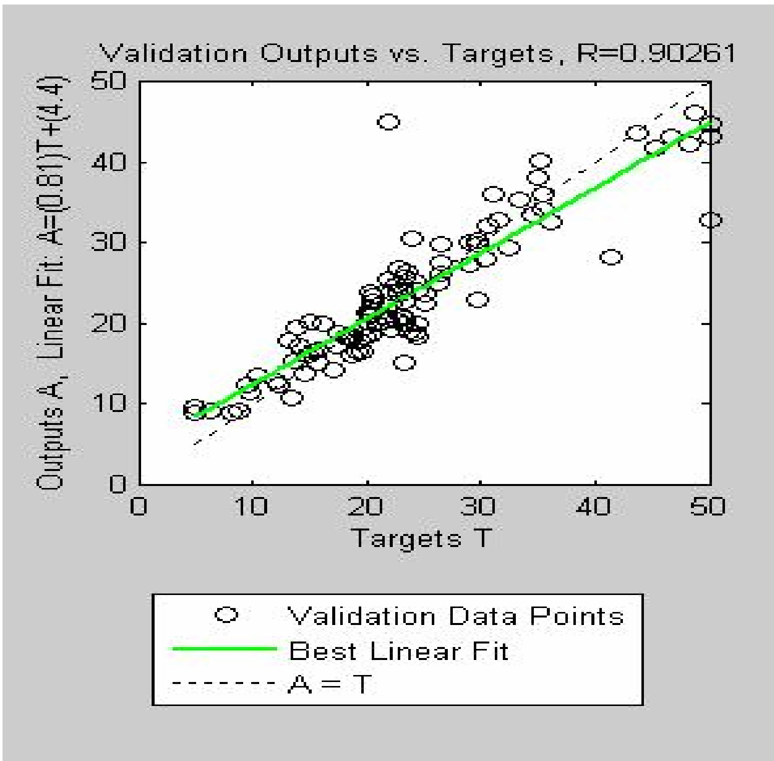


Fig 4.4 Regression Coefficient of validation data

LEARNING DATA
Buyers and Vendor attributes

Buyer Attributes	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Value of purchased item	3	3	4	4	5	2	3	4	5	2	3	2	4	4	2	4	1	4	3	2	4	4
Volume of purchased item	2	4	1	2	1	3	2	2	1	4	3	2	1	2	4	2	4	3	2	3	2	3
Criticality of item	5	3	2	2	3	2	3	3	1	4	5	5	3	3	5	4	5	3	3	4	2	3
No. of source of supply	3	2	4	4	4	3	3	4	5	2	4	4	4	4	3	5	2	4	2	2	2	3
Demand rate	3	3	2	2	2	2	3	1	2	3	3	2	1	2	3	1	3	2	2	2	3	3
Ease of transportation	4	2	2	3	2	2	4	2	3	4	3	4	3	4	4	3	5	4	1	2	2	1
Degree of engineering changes	3	2	2	2	2	3	2	3	2	3	4	4	2	2	2	4	2	3	3	3	4	3
Product variety	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Transportation cost/time	2	2	2	4	4	3	4	2	3	2	2	3	3	2	3	3	4	2	1	2	2	2
Transportation Reliability	2	2	1	2	1	2	2	2	2	1	2	2	2	3	1	2	1	2	1	1	2	2
End use of item	2	5	2	2	2	2	2	2	1	5	5	2	2	3	4	2	5	2	2	2	2	2
Manufacturing Strategy	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	2	2	2
Ease of storage	3	4	4	4	4	3	3	4	4	2	3	2	3	2	3	2	1	3	2	3	4	3
Life cycle stage	3	3	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2	3	3	3	3

Vendor Attributes	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Price	3	2	3	2	2	3	3	3	2	4	4	3	2	2	4	3	4	3	3	4	2	3
Size of production facility	3	3	1	2	2	2	2	3	2	3	2	2	3	1	3	2	3	3	2	2	2	2
Quality	1	1	1	2	1	2	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1
No. of clients	3	5	5	4	4	3	5	4	4	4	4	4	3	5	3	3	3	3	3	3	2	3
Process capability	2	5	2	5	5	3	2	2	5	2	1	1	2	5	2	2	2	2	1	2	2	2
Vendor location	2	2	2	5	5	5	4	2	5	2	2	3	3	3	3	3	3	1	1	2	1	2

Table 4.1 Attribute Rating for different Buyer-Vendor-Product Sample

LEARNING DATA

Buyers and Vendor attributes

Buyer Attributes	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
Value of purchased item	3	5	3	2	5	1	5	5	4	3	4	4	5	5	5	3	3	4	2	5	4	1
Volume of purchased item	4	1	2	3	1	3	1	1	2	2	1	1	1	1	1	4	2	1	3	1	1	4
Criticality of item	4	1	4	5	2	5	2	2	3	4	2	3	2	2	1	2	2	3	4	2	2	5
No. of source of supply	2	3	3	3	4	3	4	5	2	3	4	3	4	4	5	3	3	3	3	4	4	2
Demand rate	2	1	2	2	2	2	2	1	3	2	2	2	2	2	2	2	2	2	3	3	2	4
Ease of transportation	4	2	4	3	2	4	1	2	2	2	3	2	3	2	2	3	4	2	3	2	4	5
Degree of engineering changes	4	1	3	3	2	3	2	2	2	3	2	2	2	2	2	2	2	2	3	1	1	4
Product variety	1	4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Transportation cost/time	3	1	4	3	2	3	2	2	2	2	2	2	2	2	2	3	3	2	3	2	5	3
Transportation Reliability	2	1	2	2	2	1	2	1	2	2	3	2	1	2	2	2	2	2	2	2	2	1
End use of item	2	2	2	2	2	2	2	2	2	2	2	2	3	2	3	5	2	2	2	3	3	5
Manufacturing Strategy	2	2	3	3	3	3	3	3	4	4	4	4	4	4	4	4	3	3	3	3	4	3
Ease of storage	2	4	3	3	4	2	4	4	4	4	3	4	2	3	4	4	3	4	3	5	3	2
Life cycle stage	3	3	1	1	1	1	1	1	3	1	3	1	3	3	2	3	3	3	3	3	1	3

Vendor Attributes	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
Price	4	2	2	3	3	4	2	2	2	3	2	3	3	2	2	4	3	2	4	2	2	5
Size of production facility	1	2	1	2	3	1	1	2	1	2	3	3	2	2	2	3	2	3	3	1	2	3
Quality	1	1	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1	2	1	1	1	1
No. of clients	5	3	4	4	3	5	5	5	4	3	3	3	4	4	3	5	3	3	1	5	4	5
Process capability	1	5	2	1	3	1	2	5	2	2	3	4	2	4	4	2	3	3	2	5	5	1
Vendor location	3	2	5	4	3	3	2	4	2	5	3	2	3	2	3	3	3	3	3	3	5	3

Table 4.1 Attribute Rating for different Buyer-Vendor-Product Sample

LEARNING DATA

Buyers and Vendor attributes

Buyer Attributes	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
Value of purchased item	3	4	2	1	1	1	3	4	3	4	1	2	3	5	4	1	5	4	4	4	3	4	3
Volume of purchased item	2	1	2	3	3	3	2	3	3	2	3	2	2	1	2	2	1	2	2	1	2	1	2
Criticality of item	3	3	3	5	5	5	5	4	2	4	5	4	4	2	3	5	3	2	3	2	3	2	4
No. of source of supply	3	3	3	2	3	2	3	3	3	3	3	2	2	3	3	3	4	4	2	3	3	3	3
Demand rate	2	2	2	2	2	2	2	2	3	2	3	2	2	2	2	2	2	3	1	2	2	2	2
Ease of transportation	3	2	3	3	3	4	3	3	5	4	4	3	2	4	3	4	4	1	3	2	2	5	2
Degree of engineering changes	1	2	2	3	4	3	3	4	3	2	4	3	3	2	2	2	4	3	2	2	2	2	3
Product variety	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4	1	1	1	1	1	1
Transportation cost/time	2	3	2	2	2	4	5	3	3	3	3	3	2	3	2	3	3	3	2	1	4	4	2
Transportation Reliability	2	1	2	1	2	2	2	1	2	2	1	2	3	2	2	1	2	2	3	2	2	2	2
End use of item	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Manufacturing Strategy	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Ease of storage	2	4	4	4	2	2	2	3	3	3	3	2	2	1	4	2	2	4	3	5	3	2	4
Life cycle stage	3	3	1	1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

Vendor Attributes	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
Price	3	3	3	4	3	4	2	4	3	3	4	3	4	3	2	4	2	3	3	3	4	2	3
Size of production facility	3	1	2	2	2	2	1	1	2	2	2	2	2	2	2	1	3	3	2	2	2	3	3
Quality	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	3	2	1	1	1	2	1
No. of clients	3	4	4	4	3	3	3	4	3	4	3	3	3	3	1	1	3	1	3	1	3	3	3
Process capability	3	1	2	1	1	2	1	1	3	1	2	1	1	2	2	1	3	4	2	2	2	2	2
Vendor location	3	3	3	3	3	3	5	3	2	5	3	3	3	3	3	3	3	3	3	3	3	3	3

Table 4.1 Attribute Rating for different Buyer-Vendor-Product Sample

LEARNING DATA

Buyers and Vendor attributes

Buyer Attributes	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89
Value of purchased item	2	4	5	5	5	4	2	2	5	5	3	2	3	3	2	4	1	4	3	2	4	4
Volume of purchased item	2	2	1	1	1	2	3	3	1	1	2	3	2	2	4	2	4	3	2	3	2	3
Criticality of item	5	2	1	1	2	4	4	4	2	2	4	4	4	4	5	4	5	3	3	4	2	3
No. of source of supply	3	2	3	2	4	4	3	3	4	4	3	3	3	3	3	5	2	4	2	2	2	3
Demand rate	1	2	2	2	2	3	2	2	1	1	2	2	2	2	3	1	3	2	2	2	3	3
Ease of transportation	4	3	1	1	3	4	4	4	1	1	3	4	4	4	4	3	5	4	1	2	2	1
Degree of engineering changes	3	1	1	1	2	2	3	2	2	1	2	2	2	2	2	4	2	3	3	3	4	3
Product variety	1	1	1	1	3	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Transportation cost/time	3	2	4	4	3	2	4	4	2	2	3	2	3	3	3	3	4	2	1	2	2	2
Transportation Reliability	1	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	1	2	1	1	2	2
End use of item	2	1	1	1	1	3	2	2	3	3	2	2	2	2	4	2	5	2	2	2	2	2
Manufacturing Strategy	2	3	3	3	3	3	4	4	4	4	4	4	4	4	4	4	4	4	2	2	2	2
Ease of storage	1	4	4	5	3	2	4	2	4	4	4	2	3	3	3	2	1	3	2	3	4	3
Life cycle stage	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3

Vendor Attributes	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89
Price	4	2	2	2	3	4	4	3	3	3	3	3	3	3	4	3	4	3	3	4	2	3
Size of production facility	2	3	1	1	2	1	3	2	3	2	2	2	2	2	3	2	3	3	2	2	2	2
Quality	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1
No. of clients	2	3	3	4	4	5	1	2	4	4	3	3	3	3	3	3	3	3	3	3	2	3
Process capability	2	5	5	5	2	1	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2
Vendor location	3	3	5	5	3	2	3	3	3	3	3	3	3	3	3	3	3	1	1	2	1	2

Table 4.1 Attribute Rating for different Buyer-Vendor-Product Sample

LEARNING DATA
Buyers and Vendor attributes

Buyer Attributes	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111
Value of purchased item	3	5	3	2	5	1	5	5	4	3	4	4	5	5	5	3	3	4	2	5	4	1
Volume of purchased item	4	1	2	3	1	3	1	1	2	2	1	1	1	1	1	4	2	1	3	1	1	4
Criticality of item	4	1	4	5	2	5	2	2	3	4	2	3	2	2	1	2	2	3	4	2	2	5
No. of source of supply	2	3	3	3	4	3	4	5	2	3	4	3	4	4	5	3	3	3	3	4	4	2
Demand rate	2	1	2	2	2	2	2	1	3	2	2	2	2	2	2	2	2	2	3	3	2	4
Ease of transportation	4	2	4	3	2	4	1	2	2	2	3	2	3	2	2	3	4	2	3	2	4	5
Degree of engineering changes	4	1	3	3	2	3	2	2	2	3	2	2	2	2	2	2	2	2	3	1	1	4
Product variety	1	4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Transportation cost/time	3	1	4	3	2	3	2	2	2	2	2	2	2	2	2	3	3	2	3	2	5	3
Transportation Reliability	2	1	2	2	2	1	2	1	2	2	3	2	1	2	2	2	2	2	2	2	2	1
End use of item	2	2	2	2	2	2	2	2	2	2	2	2	3	2	3	5	2	2	2	3	3	5
Manufacturing Strategy	2	2	3	3	3	3	3	3	4	4	4	4	4	4	4	4	3	3	3	3	4	3
Ease of storage	2	4	3	3	4	2	4	4	4	4	3	4	2	3	4	4	3	4	3	5	3	2
Life cycle stage	3	3	1	1	1	1	1	1	3	1	3	1	3	3	2	3	3	3	3	3	1	3

Vendor Attributes	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111
Price	4	2	2	3	3	4	2	2	2	3	2	3	3	2	2	4	3	2	4	2	2	5
Size of production facility	1	2	1	2	3	1	1	2	1	2	3	3	2	2	2	3	2	3	3	1	2	3
Quality	1	1	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1	2	1	1	1	1
No. of clients	5	3	4	4	3	5	5	5	4	3	3	3	4	4	3	5	3	3	1	5	4	5
Process capability	1	5	2	1	3	1	2	5	2	2	3	4	2	4	4	2	3	3	2	5	5	1
Vendor location	3	2	5	4	3	3	2	4	2	5	3	2	3	2	3	3	3	3	3	3	5	3

Table 4.1 Attribute Rating for different Buyer-Vendor-Product Sample

LEARNING DATA
Buyers and Vendor attributes

Buyer Attributes	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133
Value of purchased item	3	4	2	1	1	1	3	4	3	4	1	2	3	5	4	1	5	4	4	4	3	4
Volume of purchased item	2	1	2	3	3	3	2	3	3	2	3	2	2	1	2	2	1	2	2	1	2	1
Criticality of item	3	3	3	5	5	5	5	4	2	4	5	4	4	2	3	5	3	2	3	2	3	2
No. of source of supply	3	3	3	2	3	2	3	3	3	3	3	2	2	3	3	3	4	4	2	3	3	3
Demand rate	2	2	2	2	2	2	2	2	3	2	3	2	2	2	2	2	2	3	1	2	2	2
Ease of transportation	3	2	3	3	3	4	3	3	5	4	4	3	2	4	3	4	4	1	3	2	2	5
Degree of engineering changes	1	2	2	3	4	3	3	4	3	2	4	3	3	2	2	2	4	3	2	2	2	2
Product variety	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4	1	1	1	1	1
Transportation cost/time	2	3	2	2	2	4	5	3	3	3	3	3	2	3	2	3	3	3	2	1	4	4
Transportation Reliability	2	1	2	1	2	2	2	1	2	2	1	2	3	2	2	1	2	2	3	2	2	2
End use of item	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Manufacturing Strategy	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Ease of storage	2	4	4	4	2	2	2	3	3	3	3	2	2	1	4	2	2	4	3	5	3	2
Life cycle stage	3	3	1	1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

Vendor Attributes	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133
Price	3	3	3	4	3	4	2	4	3	3	4	3	4	3	2	4	2	3	3	3	4	2
Size of production facility	3	1	2	2	2	2	1	1	2	2	2	2	2	2	2	1	3	3	2	2	2	3
Quality	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	3	2	1	1	1	2
No. of clients	3	4	4	4	3	3	3	4	3	4	3	3	3	3	1	1	3	1	3	1	3	3
Process capability	3	1	2	1	1	2	1	1	3	1	2	1	1	2	2	1	3	4	2	2	2	2
Vendor location	3	3	3	3	3	3	5	3	2	5	3	3	3	3	3	3	3	3	3	3	3	3

Table 4.1 Attribute Rating for different Buyer-Vendor-Product Sample

LEARNING DATA
Buyers and Vendor attributes

Buyer Attributes	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155
Value of purchased item	3	2	4	5	5	5	4	2	2	5	5	3	2	3	3	3	3	4	4	5	2	3
Volume of purchased item	2	2	2	1	1	1	2	3	3	1	1	2	3	2	2	2	4	1	2	1	3	2
Criticality of item	4	5	2	1	1	2	4	4	4	2	2	4	4	4	4	5	3	2	2	3	2	3
No. of source of supply	3	3	2	3	2	4	4	3	3	4	4	3	3	3	3	3	2	4	4	4	3	3
Demand rate	2	1	2	2	2	2	3	2	2	1	1	2	2	2	2	3	3	2	2	2	2	3
Ease of transportation	2	4	3	1	1	3	4	4	4	1	1	3	4	4	4	4	2	2	3	2	2	4
Degree of engineering changes	3	3	1	1	1	2	2	3	2	2	1	2	2	2	2	3	2	2	2	2	3	2
Product variety	1	1	1	1	1	3	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Transportation cost/time	2	3	2	4	4	3	2	4	4	2	2	3	2	3	3	2	2	2	4	4	3	4
Transportation Reliability	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	1	2	2
End use of item	2	2	1	1	1	1	3	2	2	3	3	2	2	2	2	2	5	2	2	2	2	2
Manufacturing Strategy	2	2	3	3	3	3	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Ease of storage	4	1	4	4	5	3	2	4	2	4	4	4	2	3	3	3	4	4	4	4	3	3
Life cycle stage	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3

Vendor Attributes	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155
Price	3	4	2	2	2	3	4	4	3	3	3	3	3	3	3	3	2	3	2	2	3	3
Size of production facility	3	2	3	1	1	2	1	3	2	3	2	2	2	2	2	3	3	1	2	2	2	2
Quality	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	2	1	2	1
No. of clients	3	2	3	3	4	4	5	1	2	4	4	3	3	3	3	3	5	5	4	4	3	5
Process capability	2	2	5	5	5	2	1	2	2	2	2	2	2	2	2	2	5	2	5	5	3	2
Vendor location	3	3	3	5	5	3	2	3	3	3	3	3	3	3	3	2	2	2	5	5	5	4

Table 4.1 Attribute Rating for different Buyer-Vendor-Product Sample

LEARNING DATA

Buyers and Vendor attributes

Buyer Attributes	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177
Value of purchased item	4	5	2	3	2	4	4	2	4	1	4	3	2	4	4	3	5	3	2	5	1	5
Volume of purchased item	2	1	4	3	2	1	2	4	2	4	3	2	3	2	3	4	1	2	3	1	3	1
Criticality of item	3	1	4	5	5	3	3	5	4	5	3	3	4	2	3	4	1	4	5	2	5	2
No. of source of supply	4	5	2	4	4	4	4	3	5	2	4	2	2	2	3	2	3	3	3	4	3	4
Demand rate	1	2	3	3	2	1	2	3	1	3	2	2	2	3	3	2	1	2	2	2	2	2
Ease of transportation	2	3	4	3	4	3	4	4	3	5	4	1	2	2	1	4	2	4	3	2	4	1
Degree of engineering changes	3	2	3	4	4	2	2	2	4	2	3	3	3	4	3	4	1	3	3	2	3	2
Product variety	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4	1	1	1	1	1
Transportation cost/time	2	3	2	2	3	3	2	3	3	4	2	1	2	2	2	3	1	4	3	2	3	2
Transportation Reliability	2	2	1	2	2	2	3	1	2	1	2	1	1	2	2	2	1	2	2	2	1	2
End use of item	2	1	5	5	2	2	3	4	2	5	2	2	2	2	2	2	2	2	2	2	2	2
Manufacturing Strategy	4	4	4	4	4	4	4	4	4	4	4	2	2	2	2	2	2	3	3	3	3	3
Ease of storage	4	4	2	3	2	3	2	3	2	1	3	2	3	4	3	2	4	3	3	4	2	4
Life cycle stage	3	3	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	1	1	1	1	1

Vendor Attributes	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177
Price	3	2	4	4	3	2	2	4	3	4	3	3	4	2	3	4	2	2	3	3	4	2
Size of production facility	3	2	3	2	2	3	1	3	2	3	3	2	2	2	2	1	2	1	2	3	1	1
Quality	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1
No. of clients	4	4	4	4	4	3	5	3	3	3	3	3	3	2	3	5	3	4	4	3	5	5
Process capability	2	5	2	1	1	2	5	2	2	2	2	1	2	2	2	1	5	2	1	3	1	2
Vendor location	2	5	2	2	3	3	3	3	3	3	1	1	2	1	2	3	2	5	4	3	3	2

Table 4.1 Attribute Rating for different Buyer-Vendor-Product Sample

LEARNING DATA

Buyers and Vendor attributes

Buyer Attributes	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	178	179	180
Value of purchased item	5	4	3	4	4	5	5	5	3	3	4	2	5	4	1	3	5	4	3
Volume of purchased item	1	2	2	1	1	1	1	1	4	2	1	3	1	1	4	2	1	2	2
Criticality of item	2	3	4	2	3	2	2	1	2	2	3	4	2	2	5	3	2	3	4
No. of source of supply	5	2	3	4	3	4	4	5	3	3	3	3	4	4	2	3	5	2	3
Demand rate	1	3	2	2	2	2	2	2	2	2	2	3	3	2	4	2	1	3	2
Ease of transportation	2	2	2	3	2	3	2	2	3	4	2	3	2	4	5	3	2	2	2
Degree of engineering changes	2	2	3	2	2	2	2	2	2	2	2	3	1	1	4	1	2	2	3
Product variety	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Transportation cost/time	2	2	2	2	2	2	2	2	3	3	2	3	2	5	3	2	2	2	2
Transportation Reliability	1	2	2	3	2	1	2	2	2	2	2	2	2	2	1	2	1	2	2
End use of item	2	2	2	2	2	3	2	3	5	2	2	2	3	3	5	2	2	2	2
Manufacturing Strategy	3	4	4	4	4	4	4	4	4	3	3	3	3	4	3	3	3	4	4
Ease of storage	4	4	4	3	4	2	3	4	4	3	4	3	5	3	2	2	4	4	4
Life cycle stage	1	3	1	3	1	3	3	2	3	3	3	3	3	1	3	3	1	3	1

Vendor Attributes	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	178	179	180
Price	2	2	3	2	3	3	2	2	4	3	2	4	2	2	5	3	2	2	3
Size of production facility	2	1	2	3	3	2	2	2	3	2	3	3	1	2	3	3	2	1	2
Quality	1	1	1	1	2	1	2	1	1	1	2	1	1	1	1	2	1	1	1
No. of clients	5	4	3	3	3	4	4	3	5	3	3	1	5	4	5	3	5	4	3
Process capability	5	2	2	3	4	2	4	4	2	3	3	2	5	5	1	3	5	2	2
Vendor location	4	2	5	3	2	3	2	3	3	3	3	3	3	5	3	3	4	2	5

Table 4.1 Attribute Rating for different Buyer-Vendor-Product Sample

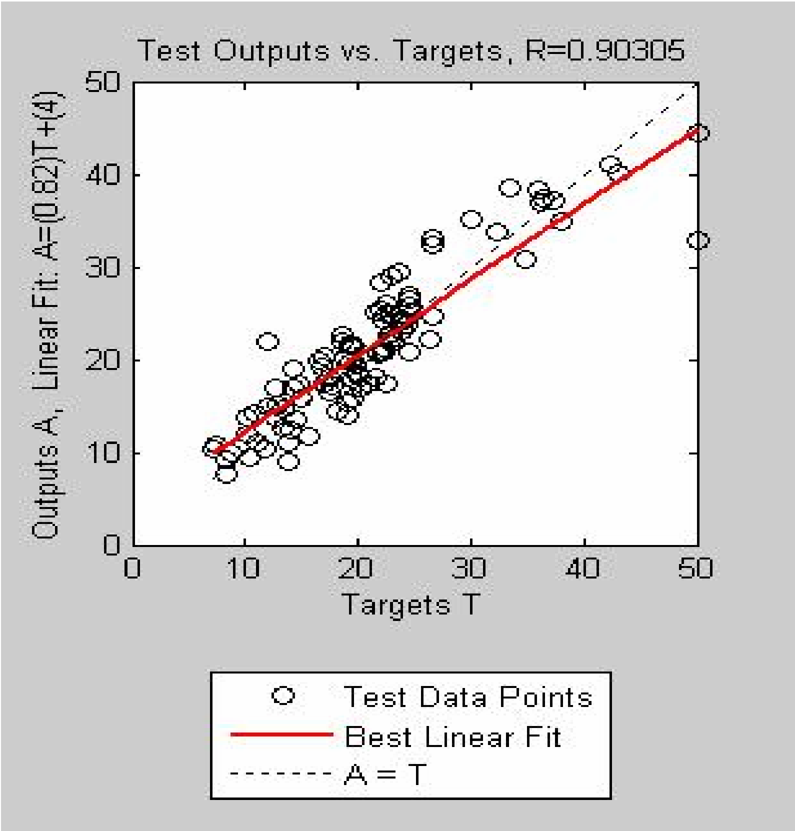


Fig 4.5 Regression coefficient of test data

Regression coefficients based on the data are 0.9439 for training set, 0.90261 for validation set and 0.90305 for test data set shows that the learning of the network is proper and now this application can be used.

4.5 Testing and Validation: - Regression coefficients itself showing that the network is properly learned, and can be used. Here are some sets of input and corresponding output taken from different companies and in order to validate the application, comparison of the output from neural network and actual data is given below.

Table 4.2 Comparison between ratings of vendor attributes (Actual vs. ANN)

Set 1			Set 2			Set 3		
1	2	1	2	3	3	3	4	4
3	4	4	3	2	2	3	1	2
4	3	3	4	4	3	4	3	3
3	3	3	3	3	3	3	4	3
2	2	3	2	2	3	2	2	1
3	3	2	2	3	2	4	3	3
3	3	3	3	2	2	3	3	2
1	1	1	1	1	1	1	1	1
2	2	3	4	3	3	2	4	4
2	2	2	2	1	2	1	2	2
2	2	2	2	2	2	2	2	2
3	3	3	4	4	4	3	3	3
3	3	4	3	3	4	4	4	3
3	3	1	3	3	3	3	3	3
Actual			Actual			Actual		
4	3	4	2	3	3	2	2	3
2	2	3	2	2	3	1	2	1
1	1	1	1	1	2	1	1	1
3	4	3	3	4	3	4	3	4
1	2	1	1	2	2	2	2	3
3	2	4	5	4	4	2	4	4
Neural network			Neural network			Neural network		
4	3	4	2	3	3	2	2	3
2	2	3	2	2	3	1	2	1
1	1	1	1	1	2	1	1	1
4	4	3	3	4	3	4	3	4
1	2	1	1	2	2	2	2	3
3	2	3	5	5	4	2	4	3

Set 4			Set 5			Set 6		
4	5	5	4	4	4	3	3	4
1	1	1	4	4	4	2	4	1
2	3	3	4	5	5	5	3	2
4	4	4	2	2	1	3	2	4
2	1	2	4	4	4	3	3	2
3	4	3	4	4	4	4	2	2
2	2	2	2	2	2	3	2	2
1	1	1	1	1	1	1	1	1
3	4	4	5	4	4	2	2	2
2	3	2	1	1	2	2	2	1
2	2	2	5	5	5	2	5	2
4	4	4	3	3	3	4	4	4
3	2	3	2	2	2	3	4	4
3	3	3	3	3	3	3	3	3
Actual			Actual			Actual		
2	2	2	3	3	4	3	2	3
2	1	1	3	2	2	3	3	1
2	1	1	1	1	1	1	1	1
3	3	4	5	5	5	3	5	5
4	3	4	1	2	2	2	5	2
3	4	5	5	5	5	2	2	2
Neural network			Neural network			Neural network		
2	2	2	3	3	4	3	2	3
2	1	1	3	2	2	3	3	1
2	1	1	1	1	1	1	1	1
3	3	4	4	5	4	3	5	5
4	3	4	1	2	2	2	5	3
4	4	5	5	5	5	2	2	2

The color cells shows the variation in the output of the neural network basically the variation is in two factors 1) Number of clients and 2) Vendor location like in case of set 1

a) Number of client should be SOME but result of neural network is showing MANY
b) Vendor location is 100-500 km but result of neural network is 20-100 Km

Similarly, in case of set 2

a) Vendor location is 100-500 km but result of neural network is more than 500 Km.

Similarly, in case of set 3

a) Vendor location is 100-500 km but result of neural network is 20-100 Km

Similarly, in case of set 4

a) Vendor location is 20-100 km but result of neural network is 100-500 Km

Similarly, in case of set 5

a) Vendor location is more than 500 km but result of neural network is 100-500 km.

In India we do not have or very less dedicated supplier which supplies only to one vendor, generally all suppliers have more than one client in the same way there are no specified locations for suppliers, for most of the companies suppliers are scattered all over hence the variations in these two attributes are more.

Chapter 5

CONCLUSION AND SCOPE OF FUTURE WORK

5.1 Conclusion

Vendor selection problem (VSP) is an area of tremendous importance in the effective management of an organization. The material and equipment supplied from the vendors play an important role in the over all growth of an organization. Hence, it is important to select the potential vendors so that different objectives are achieved. Similarly, reliable vendors also lead to less number of vendors in the chain. Hence, the optimization of vendor-base is needed to identify better performing vendors in a supply chain. VSP has been considered as a complex problem due to several reasons:

(i) Selected vendors need to be evaluated on more than one criterion. Dickson (1966) identified 23 criteria for vendor selection, while Dempsey (1978) describes 18 criteria.

(ii) Individual vendors may have different performance characteristics for different criteria.

(iv) Suppliers may impose constraints on the supplying process so as to meet their own minimum order quantities or maximum order quantities that may be based on their production capacity.

(v) There may be time constraints on the delivery of items. Within these time constraints, some criteria for supplying the items may become important, while other criteria may not be the dominant ones.

In this work an approach is proposed for selecting the most preferred set of vendor attributes as per the attributes of the buyer. The present study can be concluded in the following steps:

1) The proposed application is more effective than the deterministic methods for

handling the real situation.

2) Results will be keep on improving the amount of learning data is increased.

3) Code developed for the selection of vendor attributes can be used for many

other applications where both input and output parameters are more than one.

In conclusion, a firm belief is hold that the underlying concept of this approach is both rational and comprehensible. Consideration of relationships between criteria presented in this project provides organizations with a way to devise and refine adequate attributes of a vendor and alleviate the risk of selecting sub-optimal solutions.

5.2 Scope of future work

As we know that there are number of buyer attributes which effects the selection of the vendor attributes so that all the requirement of a buyer are fulfilled with maximum efficiency and minimum cost. As the attributes of one buyer are always different than other buyer hence in future one can add up more attributes of buyer as well as vendor so that the application become more versatile. Secondly the proposed model can be extended to handle the inherent uncertainty and imprecision of human judgment.

REFERENCES

1. Charnes, A, Cooper, WW and Ferguson, R (1955) “Optimal estimation of executive compensation by linear programming, Management Science”, 1, 138-151.

2. Ansari, A., and Modarress, B. (1986), "Just-in-time purchasing: Problems and solutions", Journal of Purchasing and Materials Management, 11-15.
3. Ansari, A., and Modarress, B. (1980), "JIT purchasing as a quality and productivity centre", International Journal of Production Research 26/1, 19-26.
4. Anthony, T.F., and Buffa, F.P. (1977), "Strategic purchase scheduling", Journal of Purchasing and Materials Management, 27-31.
5. Banerjee, A. (1986), "A joint economic-lot-size model for purchaser and vendor", Decision Sciences 17, 292-311.
6. Banerjee, A. (1986), "On "A quantity discount pricing model to increase vendor profits" ", Management Science 32/11, 1513-1517.
7. Bender, P.S., Brown, R.W., Isaac, M.H., and Shapiro, J.F. (1985), "Improving purchasing productivity at IBM with a normative decision support system", Interfaces 15, 106-115.
8. Benton, W.C. (1983), "Purchase quantity discount procedures and MRP", Journal of Purchasing and Materials Management, 30-34.
9. Benton, W.C. (1985), "Multiple price breaks and alternative purchase lot-sizing procedures in materials requirements planning systems", International Journal of Production Research 23/5, 1025-1047.
10. Benton, W.C. (1985), "Purchase lot sizing research for MRP systems", International Journal of Production Management 6/1, 5-13.
11. Benton, W.C., and Krajewski, L. (1990), "Vendor performance and alternative manufacturing environments", Decision Sciences, 21.
12. Benton, W.C., and Whybark, O.C. (1982), "Material requirements planning (MRP and purchase discounts)", Journal of Operations Management 2/2, 137-143.
13. Bernard, P. (1989), "Managing vendor performance", Production and Inventory Management Journal, 1-7. Bragg, D.J., and Hahn, C.K. (1982), "Material requirements planning and purchasing", Journal of Purchasing and Materials Management, 17-22.

14. Browning, J.M., Zabriskie, N.B., and Huellmantel, A.B., "Strategic purchasing planning", Journal of Purchasing and Materials Management, 19-24.
15. Buffa, F.P., and Jackson, W.M. (1983), "A goal programming model for purchase planning", Journal of Purchasing and Materials Management, 27-34.
16. Burton, T.T. (1988), "JIT/repetitive sourcing strategies: "Tying the knot" With your suppliers", Production and Inventory Management Journal, 38-41.
17. Dimoulas, C, Kalliris, G, Papanikolaou, G, Petridis, V and Kalampakas, A, (2006),” Bowel-sound pattern analysis using wavelets and neural networks with application to long-term, unsupervised, gastrointestinal motility monitoring”
18. Cardozo, R.N., and Cagiey, J.W. (1971), "Experimental study of industrial buyer behavior", Journal of Marketing Research VIII, 329-934.
19. Chapman, S.N. (1989), "Just-in-time supplier inventory: An empirical implementation model", International Journal of Production Research 27/12, 1993-2007.
20. Chapman, S.N., and Carter, P.L. (1990), "'Supplier/customer inventory relationships under just in time", Decision Sciences 21, 35-51.
21. Chakravarty, A.K., and Martin, G.E. (1988), "An optimal joint buyer-seller discount pricing model", Computers and Operations Research 15/3, 271-281.
22. Cooper, S.D. (1977), "A total system for measuring delivery performance", Journal of Purchasing and Materials Management, 22-26.
23. Croell, R.C. (1980), "Measuring purchasing effectiveness", Journal of Purchasing and Materials Management, 22-26.
24. Dimla Sr., D.E. and Lister, P.M. (1999),” On-line metal cutting tool condition monitoring. II: tool-state classification using multi-layer perceptron neural networks”
25. Jeng, D.S, Cha, D. H. and Blumenstein, M,” Application of Neural Network in Civil Engineering Problems”

26. Dada, M., and Srikanth, K.N. (1987), "Pricing policies for quantity discounts", Management Science 33/10, 1247- 1252.
27. Dempsey, W.A. (1978), "Vendor selection and the buying process", Industrial Marketing Management 7, 257-267.
28. Dickson, G.W. (t966), "An analysis of vendor selection systems and decisions", Journal of Purchasing 2/1, 5-17.
29. Edwards, M.G. (1967), "Supplier management evaluation", Journal of Purchasing 3/1, 28-41.
30. Eleni Aggelogiannaki, Haralambos Sarimveis and Dimitrios Koubogiannis (2007),” Model predictive temperature control in long ducts by means of a neural network approximation tool”
31. Frazier, G.L., Spekman, R.E., and O'Neal C.R. (1988), "'Justin- time exchange relationships in industrial markets", Journal of Marketing, 52-67.
32. Franci Cus and Uros Zuperl(2005),” Approach to optimization of cutting conditions by using artificial neural networks”
33. Gaballa, A.A. (1974), "Minimum cost allocation of tenders", Operational Research Quarterly 25/3, 389-398.
34. Goyal, S.K. (1987), "Comment on: A generalized quantity discount pricing model to increase supplier's profits", Management Science 33/12,1635-36
35. Gregory, R.E. (1986), "Source selection: A matrix approach", Journal of Purchasing and Materials Management, 24-29.
36. Hahn C.K., Kim, K.H., and Kim J.S. (1986), "Costs of competition: Implications for purchasing strategy", Journal of Purchasing and Materials Management, 2-7.
37. Hahn, C.K., Pinto, P.A., and Bragg, D.J, "Just-in-time" production and purchasing", Journal of Purchasing and Materials Management, 2-10.
38. Hakansson, H., and Wootz, B. (1975), "Supplier selection in an international environment - An experimental study", Journal of Marketing Research XII, 46-51.
39. Hinkle, C.L., Robinson, P.J., and Green, P.E. (1969), "Vendor evaluation using cluster analysis", Journal of Purchasing, 49-58.

40. Ho, Chrwan-jyh, and Carter, P.L. (1988), "Using vendor capacity planning in supplier evaluation", Journal of Purchasing and Materials Management, 23-30.
41. Hwang, H., Moon, Dug Hee, and Shinn, Seong Whan (1990), "An EOQ model with quantity discounts for both purchasing price and freight cost", Computers and Operations Research 17/1, 73-78.
42. Irshad Ahmad, M. Hesham El Naggar and Akhtar Naeem Khan(2006),” Artificial neural network application to estimate kinematic soil pile interaction response parameters”
43. Jackson, G.C. (1983), "Just-in-time production: Implications for logistics managers", Journal of Business Logistics 4/2, 1-19.
44. Jacobson, R., and Aaker, D.A. (1987), "The strategic role of product quality", Journal of Marketing, 31-44. Jordan, P.C. (1987), "Purchasing decisions considering future price increases: An empirical approach", Journal of Purchasing and Materials Management, 25-30.
45. Kingsman, B.G. (1986), "Purchasing raw materials with uncertain fluctuating prices", European Journal of Operational Research 25, 358-372.
46. Klir G. , UTE H. St. Clair and Bo Yuan Fuzzy Set Theory Foundations and Applications,1997
47. Kraljic, P. (1983), "Purchasing must become supply management", Harvard Business Review, 109-117.
48. Kun Mo, Seung Jun Lee and Poong Hyun Seong (2007) “A neural network based operation guidance system for procedure presentation and operation validation in nuclear power plants”
49. Yi-Hui, L., (2007),” Evolutionary neural network modeling for forecasting the field failure data of repairable systems”
50. LaForge, L.R. (1985), "MRP lot sizing with multiple purchase discounts", Computers and Operations Research 12/6, 579- 587.
51. Lamberson, L.R., Diederich D., and Wuori, J. (1976),"Quantitative vendor evaluation", Journal of Purchasing and Materials Management, 19-28.

52. Lamm, D.V., and Vose, L.C. (1988), "Seller pricing strategies: A buyer's perspective", Journal of Purchasing and Materials Management, 9-13.
53. Lazaros S. Iliadis and Fotis Maris(2007)," An Artificial Neural Network model for mountainous water-resources management: The case of Cyprus Mountainous watersheds"
54. Lee, H.L., and Rosenblatt, M.J. (1986), "A generalized quantity discount pricing model to increase supplier's profits", Management Science 32/9, 1177-1185.
55. Levy, M., Cron, W., and Novack, R. (1985), "A decision support system for determining a quantity discount pricing policy", Journal of Business Logistics 6/2, 110-141.
56. Huang, M.L. and Hung, Y.H. (2006)," Combining radial basis function neural network and genetic algorithm to improve HDD driver IC chip scale package assembly yield"
57. Manoochehri, G.H. (1984), "Suppliers and the just-in-time concept", Journal of Purchasing and Materials Management 16-21.
58. Markowski, C.A., and Markowski, E.P. (1988), "An alternative criterion for the quantity discount decision", Journal of Purchasing and Materials Management, 131-34.
59. Mazurak, R.E., Rao, S.R., and Scotton, D.W. (1985), "Spreadsheet software applications in purchasing", Journal of Purchasing and Materials Management, 8-16.
60. McGinnis, M.A., and Hollon, C.J. (1978), "Packaging: Organization, objectives, and interactions", Journal of Business Logistics 1/1, 1-61.
61. McFillen, J.M., Reck, R.R., and Benton, W.C. (1983), "An experiment in purchasing negotiations", Journal of Purchasing and Materials Management, 2-8.
62. Michael R. Garey and David S. Johnson (1979). Computers and Intractability: A Guide to the Theory of NP-Completeness. W.H. Freeman. ISBN 0-7167-1045-5. A6: MP1: INTEGER PROGRAMMING, pg.245.

63. Mohamed A. Mahmoud and Abdullatif E. Ben-Nakhi (2006),” Neural networks analysis of free laminar convection heat transfer in a partitioned enclosure”
64. Monahan, J.P. (1984), "A quantity discount pricing model to increase vendor profits", Management Science 30/6, 720- 726.
65. Monczka, R.M., Giunipero, L.C., and Reck, R.F. (1981), "Perceived importance of supplier information", Journal of Purchasing and Materials Management, 21-29.
66. Monczka, R.M., and Trecha, S.J. (1988), "Cost-based supplier performance evaluation", Journal of Purchasing and Materials Management, 2-7.
67. Moore, D.L., and Fearon, H.E. (1972), "Computer-assisted decision-making in purchasing", Journal of Purchasing 9/4, 5-25.
68. Narasimhan, R. (1983), "An analytical approach to supplier selection", Journal of Purchasing and Materials Management, 27-32.
69. Narasimhan, R., and Stoynoff, L.K. (1986), "Optimizing aggregate procurement allocation decisions", Journal of Purchasing and Materials Management, 23-30.
70. Newman, R.G. (1988), "Insuring quality: Purchasing's role", Journal of Purchasing and Materials Management, 14-20.
71. Newman, R.G. (1988), "The buyer-suppfier relationship under just-in-time", Production and Inventory Management Journal, 45-50.
72. Newman, R.G., and Scodro, J. (1988), "Price analysis for negotiation", Journal of Purchasing and Materials Management, 8-14.
73. Pan, A.C. (1989), "Allocation of order quantity among suppliers", Journal of Purchasing and Materials Management, 36-39.
74. Payne, H.L. (1970), "Development of a supplier evaluation technique utilizing financial information", Journal of Purchasing 6/4, 21-34.
75. Roberts, B.J. (1978), "A vendor delivery rating model", Journal of Purchasing and Materials Management, 12-16.
76. Ronen, B., and Trietsch, D. (1988), "A decision support system for purchasing management of large projects", Operations Research 36/6, 882-890.

77. Rubin, P.A., Dilts, D.M., and Barron, B.A. (1983), "Economic order quantities with quantity discounts: Grandma does it best", Decision Sciences 14, 270-281.
78. Soukup, W.R. (1987), "Supplier selection strategies", Journal of Purchasing and Materials Management, 77-12.
79. Aykut, S, Golcu, M, Semiz, S. and Ergur, H.S. (2007),” Modeling of cutting forces as function of cutting parameters for face milling of satellite 6 using an artificial neural network”
80. Sharma, D., Benton, W.C., and Srivastava, R., "Competitive strategy and purchasing decisions", in: Proceedings of the 1989 Annual Conference of the Decision Sciences, Institute, 1088-1090.
81. Sheth, J.N. (1973), "A model of industrial buyer behavior", Journal of Marketing, 50-56.
82. Shore, B. (1981), "A micro-computer based purchasing information system", Journal of Purchasing and Materials Management, 18-12.
83. Siamak Serajzadeh (2006),” Prediction of temperature distribution and required energy in hot forging process by coupling neural networks and finite element analysis”
84. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein. Introduction to Algorithms, Second Edition. MIT Press and McGraw-Hill, 2001. ISBN 0-262-03293-7. Chapter 29: Linear Programming, pp.770–821.
85. Timmerman, E. (1986), "An approach to vendor performance evaluation", Journal of Purchasing and Materials Management, 2-8.
86. Treleven, M. (1987), "Single sourcing: A management tool for the quafity suppfier", Journal of Purchasing and Materials Management, 19-24.
87. Turner, I. (1988), "An independent system for the evaluation of contract tenders", Journal of Operational Research Society 39/6, 551-561.
88. Tuncay Erzurumlu and Hasan Oktem (2005),” Comparison of response surface model with neural network in determining the surface quality of moulded parts”

89. Wagner, J., Ettenson, R., and Parrish, J. (1989), "Vendor selection among retail buyers: An analysis by merchandise division", Journal of Retailing 65/1, 58-
90. Wen-Chin Chen and Shou-Wen Hsu (2007)," A neural-network approach for an automatic LED inspection system"
91. Wieters, C.D. (1976), "Influences on the design and use of vendor performance rating systems", Journal of Purchasing and Materials Management, 31-35.
92. Wind, Y., and Robinson, P.J. (1968), "The determinants of vendor selection: The evaluation function approach", Journal of Purchasing and Materials Management, 29-41.
93. Zuperl, U, Cus, F, Mursec, B. and Ploj, T. (2004) "A hybrid analytical-neural network approach to the determination of optimal cutting conditions", Journal of Materials Processing Technology 157–158 (2004) 82–90
94. Srinivas, V. and Ramanjaneyulu, K. (2007)," An integrated approach for optimum design of bridge decks using genetic algorithms and artificial neural networks"
95. Zumray Dokur (2006)." A unified framework for image compression and segmentation by using an incremental neural network"

ANNEXURE 1

QUESTIONNAIRE (FACTORS EFFECTING VENDORE SELECTION DECISIONS)

(Rating of Buyer- Vendor factors)

Buyer Name:- **Vendor Name:-**

Product Description:-

BUYER FACTORS						
S.No.	**Factors**	**Characteristics**				
		1	2	3	4	5
1	Value of purchased item	A class	AB class	B class	BC class	C class
2	Volume of purchased item	Very large	Large	Medium	Small	1 or 2 Product
3	Criticality of item	Low desirable	Desirable	Essential	Vital	Highly vital
4	No. of source of supply	Single	Double	Some	Many	Too many
5	Demand rate	V. high	High	Medium	Low	Very low
6	Ease of transportation	V.easy	Easy	Average	Difficult	V.difficuly
7	Degree of engineering changes	Never	Occasionally	Frequent	Very frequently	
8	Product variety	Single	Double	Some	Many	Toomany
9	Transportation cost/time	V.low	Low	Average	High	V.high
10	Transportation Reliability	V.good	Good	Average	Poor	V.poor
11	End use of item	Packing/Assembly	Manufacturing	Consumable	Spare	Tool
12	Manufacturing Strategy	JIT	JIT like policy	Hybrid policy	JIC	
13	Ease of storage	V. difficult	Difficult	Average	Easy	Very easy
14	Life cycle stage	Maturity	Steady	Growth	Introduction	Declining

VENDOR FACTORS						
S.No.	**Factors**	**Characteristics**				
		1	2	3	4	5
1	Price	Very low	Low	Moderate	High	Very high

2	Size of production facility	Very large	Large	Medium	Small	Very small
3	Quality	100% accepted	Accepted with rectification	Accepted with rejection	Not accepted	
4	No. of clients	Single	Double	Some	Many	Too many
5	Process capability	R&D jobs	Can work on new designs	Do design changes but help is required	Not capable	
6	Vendor location	0-5 kms	5-20 kms	20-100 kms	100-500 kms	More than 500 kms

SIGNATURE

ANNEXURE 2

BUYER – VENDOR – PRODUCT LIST FOR ANN

S. No.	NAME OF COMPANIES	VENDOR	PRODUCTS
1	PL Display Device Limited	Thermocare Limited	Burner assembly
		Micro Flow Control	Process control valves
		Fardes Marshaels	Control and instrumentations
		ENG India rubber pvt limited	Fabrication rubber lining
		Chem Bond Engg. Services	Water treatment plant chemical
		Micro Tech Engg.	Spares for air compressors
		Hguru Industries	Pressure gauge, Temperature gauge
		Urjex Boiler Pvt Limited	Boiler
		MTS Water	Micro filer membrane
2	Hyundai Motors India Limited	Rana Madras Limited	Streeing axel
		Sundaram Clayton Limited	Aluminium casting
		Pricol Limited	Meters
		Break India Limited	Breaks
		Lucas	Battery
		Sundaram Fasteners	Fasteners
3	Honda Motor Cycle and Scooter India (pvt) Limited	Sansera Engg. Private Limited	Gear shifting fork
		Ronak Automative Components Ltd	Gears
		Allied Nippon	Break Shoes
		Oswal Die Casting	Engine Casting
		Minda Industries	Wiring Harness
		Laxmi Precisions Tools	Fasteners
4	Minda Horn Divison	Aumdacro coating	Dacro coating
		Asian Semi Conductors Pvt Limited	Diode ST make
		Anmol Udhyog	Steel metal parts
		Guru Nanak tools	Brackets

		Hind Associates	Silica gel
		Elin Electronics Ltd	Horn spring
		Viswash Enterprises	Greese
		J.S Enterprises	Pallets and Palletisings
5	GEMI Motors India Pvt Ltd	Kushwaha Engg. Tools	Sheet metal components
		Lark Wire Private Limited	Magnetic wires
		Kay Bee Casting	Aluminium end shield
		Zavenir Duaberrt Limited	VCI bags
6	Denso Haryana Pvt Limited	Neel Kamal Ltd.	Plastic
		Shri Sai Limited	Cushion Packaging
		Laxmi M/C tools	Tools, Jigs and Fixtures
		Assab Sai Pad	Ferrous raw materials
		Motherson sumi systems ltd	Wire for motor Winding
7	Whirl Pool Limited	Bhushan Steel Limited	Plates
		Techmsech India Limited	Compressors
8	Maruti Udyog Limited	Shri Ram Pistons and Rings Limited	Pistons
		Suzuki Power	Cylinder Head
		Sansera Engg. Private Limited	Connecting Rod
		Munjalshowa Limited	Shocket
		Sharda Motors Private Limited	Sheet Frame
		NRB Bearing	Bearings
		Sunbeam Auto Limited	Engine Casting
		Sona Koya Streeing System Limited	Rack and Pinion power streeing
		Yaman Industries	Front axel part
		Omax Auto limited	Head lights
9	Hero Honda Limited	Hema engineering	Swing arm
		Sunbeam Auto Limited	Engine Casting

		A.G. Industries	Plastic Parts
		Allied Nippon	Horn
		Autofit Limited	Wheel Assembly
		Automax Limited	Main Stand
		Ricco Auto	Hub
		Lomax Auto Limited	Head lights
		Sandhar Locking	Locking Devices
		Omax Auto limited	Frame Body Sub Assembly
10	Coco Cola India Limited	Orienta'l Enclosures	Crowns
		Nikita Plasp	Mazza sleeves
		Paper Product Limited	Labels
		MeghDoot Limited	Packaging
		Bharat Shell Limited	Lubricants
11	Sharda Motors Limited	New Pragati Udyog	Cross Plate Front Seat Back
		S.M. Industries	Support plate Frame
		Bharat and Co.	Spot welding SS pin
		Gandhi Springs Gurgoan	Spring Omni Front Seat
		Allon steel Tube Industries	CRCA Tube SKTM 11A
		Hero Cycles Limited	Rear Frame Cushion
		Bushan Steels and Strips Limited	Cushion Alto domestic & Export C.R Sheet
12	MICO India Ltd.	Aditya auto components ltd.	Harnesses
		Alcoats	Nuform rollforming automotive parts
		Auto Malleable	Castings
		Deshmukh rubbers works pvt ltd	Sealing rings
		Electromags pvt ltd	Terminal mouldings
		Indo swiss anti shock limited	Plated fasteners
		Jaycee industries	Hand tools
		Maini precision products pvt ltd.	Precision ground pins
		Hari om enterprises	Pacakaging material